ИЗМЕРИТЕЛЬНАЯ
ТЕХНИКА

Em

Number 7

July, 1959

SOVIET INSTRUMENTATION AND
CONTROL TRANSLATION SERIES

Measurement Techniques

(The Soviet Journal *Izmeritel'naya Tekhnika* in English Translation)

■ This translation of a Soviet journal on instrumentation is published as a service to American science and industry. It is sponsored by the Instrument Society of America under a grant in aid from the National Science Foundation with additional assistance from the National Bureau of Standards.

SOVIET INSTRUMENTATION AND CONTROL TRANSLATION SERIES

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The original Russian articles are translated by competent technical personnel. The translations are on a cover-to-cover basis, permitting readers to appraise for themselves the scope, status, and importance of the Soviet work.

Publication of *Izmeritel'naya Tekhnika* in English translation started under the present auspices in August, 1959, with Russian issue No. 1 of Jan.-Feb. 1958. The six issues of the 1958 volume year were published in English translation by February, 1960. Russian issue No. 1 of January, 1959 was published in March, 1960, and the twelve issues of 1959 will be published in English translation by December, 1960.

Transliteration of the names of Russian authors follows the system known as the British Standard. This system has recently achieved wide adoption in the United Kingdom, and is being adopted in 1959 by a large number of scientific journals in the United States.

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General: United States and Canada	$25.00
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Instrument Society of America
313 Sixth Avenue, Pittsburgh 22, Penna.

Translated and printed by Consultants Bureau Enterprises, Inc.

Number 7—July, 1959
English Translation Published June, 1960

Measurement Techniques

The Soviet Journal Izmeritel'naya Tekhnika in English Translation

Reported circulation of the Russian original 8,000.

Izmeritel'naya Tekhnika is an organ of the Academy of Sciences, USSR

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MEASUREMENT TECHNIQUES

1959, Number 7 July

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LET US FULFILL THE DECISIONS OF THE JUNE PLENARY SESSION OF THE CPSU CENTRAL COMMITTEE.

The plenary session of the CPSU Central Committee (June 24-29, 1959) examined the more important questions arising from the decisions of the 21st Congress of the party to further technical progress in all branches of the national economy.

The decisions adopted by the June session which pertain to the practical implementation of production-group mechanization and automation, conveyor-line installation, replacement of obsolete equipment, and raising the quality of production while decreasing its costs are all of primary importance to workers engaged in metrology.

The plenary session has set important problems before workers in scientific-research metrological and instrument-making industry institutes, design offices, industrial measuring laboratories, instrument and automation-equipment-producing shops, and state and administrative inspection agencies supervising the condition of measuring equipment in all branches of the national economy.

The development of accurate and rapid measuring techniques, resulting from efficiently designed measuring instruments; improvements in the production and use of instruments, and wide application of automatic control, will undoubtedly be valuable contributions in early attainment of the goals of the Seven-Year Plan.

Scientists, engineers and technicians are expected to assist the implementation of decisions regarding the introduction of modern technological inspection and control methods in industry and transport. The development and application of new measuring methods, instruments, and automatic regulators in improved production processes should play an important part in the general development of the national economy. The session paid particular attention to the wide application of radio and electronics in the national economy, and the use of radioactive isotopes in controlling production processes.

Also stressed was the concentration on automation of production processes to the detriment of automatic control and inspection of production as a whole. Undoubtedly, the part played by measurement techniques in automatic inspection and control of production is outstanding, and metrologists must participate in producing aggregate automation schemes and in designing the requisite measuring equipment.

The plenum emphasized the formulation of approved regulations for the development, manufacture and testing of experimentals models of new machines, equipment, instruments, articles, materials and constructions and for their mass production. This requires the development of new methods for state testing of measures and measuring instruments which would permit the introduction of new highly efficient measuring equipment. It would also be necessary to revise the list of manufactured measuring instruments and make suggestions concerning the replacement of obsolete instruments with new ones, and to propose methods for the rapid development and introduction of measuring instruments utilizing the latest achievments of science and technology.

The plenum issued an instruction for the development, over a period of two or three years of standardization techniques in the production of consumer goods as well as for radical improvement of the unification and standardization of similar articles, units, and components.

It is therefore necessary to revise the list of mass-produced measuring instruments and standardize their production. These measures should include: standardization of the basic parameters, typical sizes, technical requirements, and testing methods. Standardization should be applied to automatic-control instruments in the engineering industry, instruments for automatic checking and control of thermal parameters, as well as typical units and components.

Another principal condition for successful fulfillment of the Seven-Year Plan is further specialization and cooperation in production, especially in the instrument-making industry. Considerable effort should be devoted to improving the quality of the measures and measuring instruments. In this respect great assistance can be rendered by industrial test laboratories, and instrument and automation equipment shops in conjunction with the state measuring instruments inspection laboratories. These agencies should study the operational efficiency of measures and measuring instruments under various working conditions, discover their defects, analyze them, and make concrete suggestions to the instrument-making plants.

According to the plenum decisions, the industrial laboratories and measuring instrument shops must play a more important part in introducing new measuring equipment in production. These laboratories and shops must solve competently all the problems connected with the control of technological processes and the quality of production. The Councils of National Economy will have to revise the regulations on the activity of industrial laboratories and measuring-instrument shops. On its own initiative, the Leningrad Council of National Economy, which deserves universal support, requested the test laboratories and measuring-instrument and automation-equipment shops subordinated to it to undertake, in addition to the normal inspection of the measuring equipment and the study of the operational efficiency of instruments, the following tasks: checking the accuracy of the means and methods of measurement used in the factory according to the standards, technical specifications, and GOST's; introduction of more efficient methods of measurement in production; replacement of obsolete and worn-out instruments by modern measuring equipment; improvement in the handling and repair of instruments; and the location and estimation of losses caused by faulty, inadequate, or obsolete measuring instruments which should then be eliminated.

The important decisions raised and the appeal of the June plenary session of the CPSU Central Committee demand intensive organizational and technical work in all the spheres of the measurement art.

Metrological workers welcome and approve the decisions of the June Plenum of the CPSU CC and will do their best to implement the decisions of the 21st party congress.

LINEAR MEASUREMENTS

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EFFICIENCY OF AUTOMATIC CONTROL DEVICES

A. V. Vysotskii

When appraising the economic efficiency of automatic inspection machines, it is necessary to know the number of articles scrapped because the automatic machine makes measurement errors, due to which some of the good products are scrapped and some of the faulty articles are passed. A large amount of work in rechecking articles scrapped by the automatic machine lowers its efficiency. A knowledge of the number of good articles among those rejected by the automatic machine, as well as the number of faulty articles among those passed, will enable the machine's efficiency to be determined.

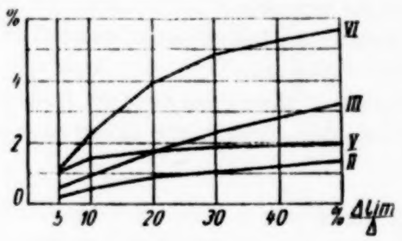


Fig. 1

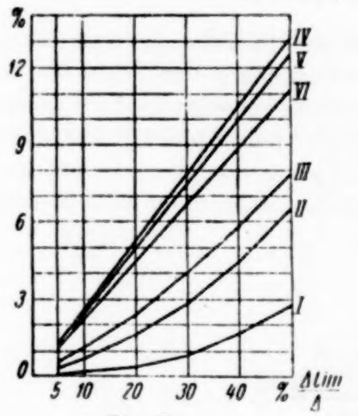


Fig. 2

Study of the measuring devices of automatic inspection machines equipped with electrical contact and pneumatic transducers showed that the distribution of random measurement errors follows the normal distribution law very closely.

The distribution law, which sometimes deviates from the normal, and the expected percentage of actual scrap should be determined experimentally, for the preliminary calculations, from the operation of the equipment under consideration.

We shall quote some calculations of the rechecking required for an automatic machine which checks one parameter for two limits.

Approximate data for multidimensional automatic machines can be obtained by adding the data obtained for each parameter since the probability of simultaneous incorrect rejection with respect to several parameters is small.

Figures 1, 2, and 3 provide graphs illustrating the number of faulty articles passed as good (Fig. 1), the quantity of good ones rejected by the automatic machine (Fig. 2) and the total quantity of articles rejected by the machine, i.e., the volume of rechecking (Fig. 3), as a function of ratio of the maximum error of the machine to the permissible production tolerance $\Delta lim/\Delta\%$ (where Δlim is the maximum error of measurement and Δ is the production tolerance) and also as a function of the percentage of scrap and the law of distribution of the article dimensions (the law of distribution of the random errors of measurement is always assumed to be normal).

The quantities in all the graphs are given in percentage of the total number of articles checked by the machine.

Curves I in graphs (Figs. 2 and 3) represent the case when the distribution of the article dimensions follows the normal law and is completely within the field of tolerance (Fig. 4,a):

$$\frac{\Delta}{2} = 3\sigma_{art}$$

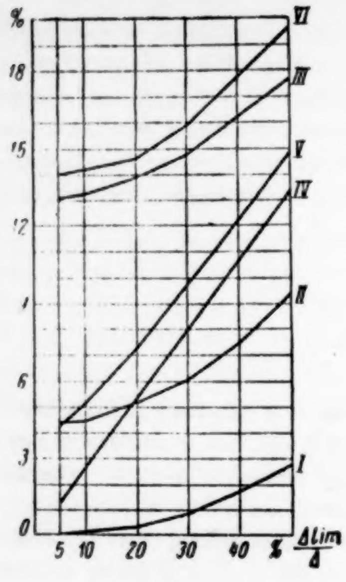


Fig. 3

where $\frac{\Delta}{2}$ is the tolerance of the article produced; σ_{art} is the mean square deviation of the article dimension (the amount by which the distribution exceeds the limit $\pm 3\sigma_{meas}$ and $\pm 3\sigma_{art}$ equal to 0.27% is omitted for simplicity of calculations).

Curves II and III on the graphs of Figs. 1, 2, and 3 represent cases when the distribution of the article dimensions follows the normal law but exceeds symmetrically the field of tolerance, i.e., when the batch contains faulty articles (Fig. 4,b).

For curve II $\Delta/2 = 2\sigma_{art}$ the excess over the field of tolerance is 0.25Δ and the total scrap from both limits is equal to 4.3%. For curve III $\Delta/2 = 1.5\sigma_{art}$ the excess over the field of tolerance is 0.5 and the total scrap equals 13.1%.

Curves IV on all the graphs (Fig. 1, 2, and 3) represents the case when the distribution of article dimensions follow the law of equal probability and is completely inside the field of tolerance (Fig. 4,c).

Curves V and VI on all the graphs represent the case when the distribution of the article dimensions follows the law of equal probability but exceeds symmetrically the field of tolerance, i.e., the batch contains faulty articles (Fig. 4,d). For curve V the excess over the field of tolerance amounts to 0.021Δ and the total scrap for both limits amounts to 4%. For curve VI the excess over the field of tolerance amounts to 0.8 and the total scrap to 14%.

It will be seen from the graphs that the distribution law of the article dimensions and the actual percentage of scrap affect the number of articles to be rechecked (Fig. 3) as much as the maximum error of the machine.

This leads to the conclusion that the efficiency in using automatic inspection depends both on the maximum measurement error of the automatic inspection machine and the accuracy of operation of the production machinery.

Even with a high accuracy of working and a small dispersion of the article dimensions, it is necessary to organize the production of articles so as to be able to increase the efficiency of automatic inspection. For instance, the normal tendency of setters to avoid faults which cannot be corrected results in the shifting of the center of distribution of article dimensions with respect to the center of the field of tolerance (curve B in Fig. 4,e) and produces a greater number of rejects by the automatic machine. Introduction of production tolerance will improve the situation by keeping the midpoint of the dimensional distribution near the center of the field of tolerance (curve A in Fig. 4,e).

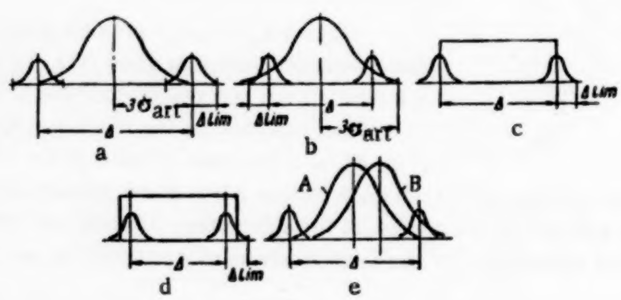


Fig. 4

AN ELECTRICAL CONTACT TRANSDUCER INCORPORATED IN A CLOCK-TYPE DIAL GAUGE

A. I. Isakov and P. K. Parfenov

Essential defects of electrical contact transducers are the absence of instantaneous value indications of the controlled variable and the sparking air-gap involved in the breaking of the contacts.

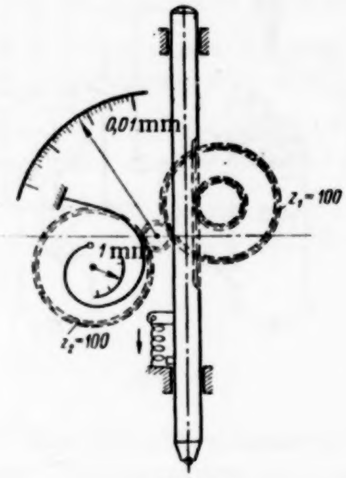


Fig. 1

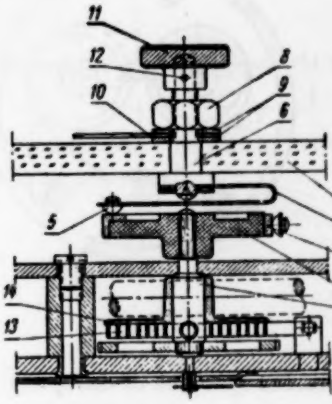


Fig. 2

The proposed electrical contact transducer eliminates them. The electrical contact system of the transducer is incorporated in a clockwork mechanism made by the "Krasnyi Instrumental'shchik" plant.

The indicator diagram is shown in Fig. 1.

Displacement of the measuring rod by 10 mm produces a complete revolution of the z_1 and z_2 gears. Moreover, owing to the fixed gearing, to every position of gears z_1 and z_2 there corresponds a definite position of the measuring rod. This circumstance provides the possibility of obtaining an electrical pulse by means of contacts closing in a predetermined position of the measuring rod.

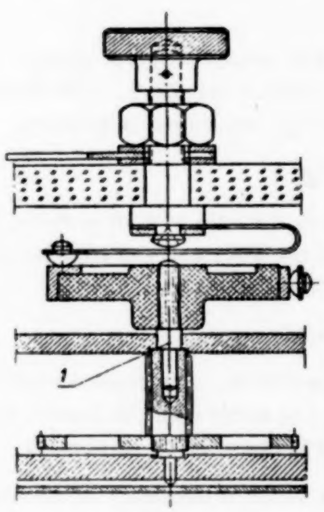


Fig. 3

For this purpose the moving portions of the contacts should be fixed to the axles of gears z_1 and z_2 and the stationary parts to the body of the device with the possibility of adjustment over a complete circle.

Figure 2 shows the fixing of the contact disc to the axle of gear z_2. Axle 1 is changed for a longer one and strengthened at the contact disc end. The bearing hole for the axle is enlarged from 1 to 1.7 mm. The contact disc made of viniplast* is firmly fixed on the axle by means of perchlorethenyl resin. A brass contact ring 3, whose upper contact surface is cut away over 180° is tightly fixed to the contact disc by means of the same resin. Contact spring 4, made of beryllium bronze with a reveted silver contact 5, is connected to spindle 6, which is fixed in a plexiglas cover 7 by means of nut 8, washer 9, and lead-out 10, to which the conductor of the measuring circuit is soldered. The transducer is set to the required position for making contact by means of knob 11, fixed to the spindle with pin 12. Nut 8 serves to fasten the spindle in the set position during operation. The hairspring which serves to eliminate play is replaced by a mainspring 13 from the "Pobeda" clock, whose principal advantages are its sloping characteristic, mechanical stability, convenient placing inside the body of the instrument by means of the fixings supplied with the spring, and its availability. Cover 14 serves to prevent the spring from bulging out.

* Russian trade name for a variety of vinylite [Publisher's note].

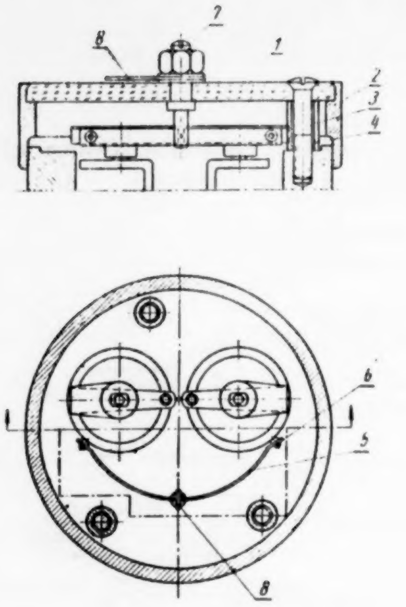


Fig. 4

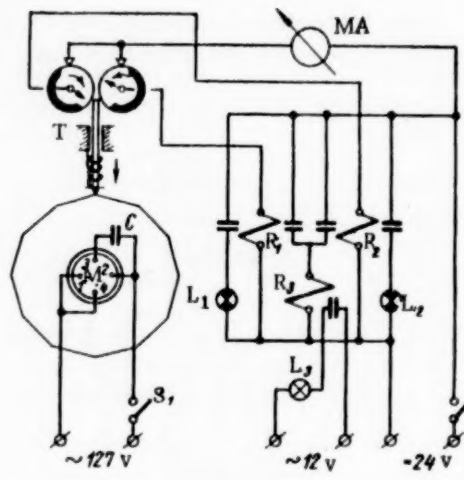


Fig. 5

The restoring torque of the spring is selected to overcome four moments of friction created by the contac , and the losses of energy in both three pairs of cylindrical gears and in the mainspring itself. Moreover, certain excess moment must be established to act as a measuring effort. The fixing of the contact system to the axle of gear z_1 is shown in Fig. 3. The required extension and strengthening of the axle for the fixing of the contact disc is attained by a special pressed-on cap 1 with external dimensions of the axle stem of gear z_2.

The contact disc wobble is limited to 0.05 mm in both cases which provides a long and reliable operation of the bronze contact springs with a minimum contact pressure.

Figure 4 shows the back cover of the transducer and the fixing of the middle, supply contact.

In order to be able to insulate the middle and the two limiting contacts shown in Figs. 2 and 3, the back cover of the indicator is replaced by plexiglas plate 1, forced into band 2. The cover is fixed to the body of the instrument by three screws 3, through distance bushes 4. The screws are fixed into normal threaded holes in the body of the instrument.

The middle contact slides along the side surfaces of both contact discs. The middle contact spring 5 is made of beryllium bronze with riveted silver contacts 6. Spring 5 is fixed to a contact spindle 7. The spindle is fixedto the cover by means of a nut, a washer, and lug 8, to which the measuring-circuit lead is soldered.

Transducer models were tested in an installation assembled as shown in Fig. 5.

A dodecahedral disc with a circumscribed diameter of 100 mm was fixed to the axle of a 10 w motor M type RD-09. The indicating transducer T under test slid over the side surface of the disc, and was adjusted so that each of its contacts was made or broken during one cycle of the measuring rod's operation.

Windings of relays R_1 and R_2 type RSM 1 were connected as transducer loads.

The common lead had a 0-30 ma milliammeter M4-2 connected in series with it. One contact each of relays R_1 and R_2 operate signal lamps L_1 and L_2, the remaining two are connected in series with the intermediate relay R_3 type MKU-48 which is used as an actuating mechanism with 50 w lamp L_3 operated by its contact.

Single pole switches S_1 and S_2 serve to switch the two test units separately which is necessary in intermediate measurements.

The current through the winding when the contacts were closed amounted to 18 ma and did not change during the tests.

The conditions of the contact surfaces was determined before and after testing by the potential drop in each of the two transducer circuits.

By measuring the potential drop along the entire contact surface of each disc at 0.5 mm intervals, before and after testing the contacts 500,000 times with 18 ma flowing through them and the 24 v winding of the dc relay, it was found that the total contact resistance increased by less than 20% of its original value and was in the limits of 0.25-0.030 ohm.

This change in the contact resistance cannot affect the operation of the circuit, since the contact resistance is completely negligible compared with that of the relay winding of 500 ohms.

The stability of the transducer setting during the entire test period remained constant at ± 0.02 mm, which is below the specified figure of 0.025 mm for the indicator.

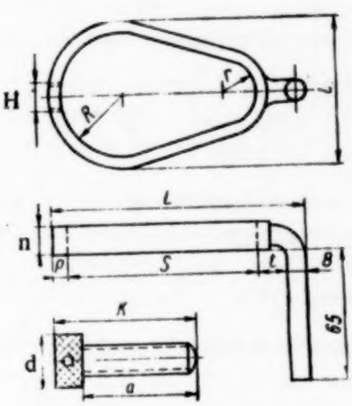
The difference in the measuring effort at the two extreme positions of the measuring rod did not exceed 60% of its initial value in any of the tested transducers.

Owing to the sliding contacts which clean themselves, there is no necessity to clean them periodically during the guaranteed 500,000 operations with allowing a few days' interruption of operation.

AN ATTACHMENT FOR AN OPTICAL DIVIDING HEAD

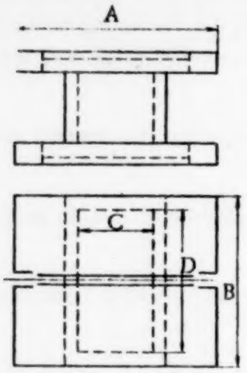
F. P. Volosevich

The optical dividing heads, manufactured by our industry, are often insufficiently used owing to the lack of auxiliary attachments. In order to increase the sphere of their application, the Kirov and other plants are now using the following attachments.



Dimensions of lugs, mm	R	r	L	l	P	S	t	n	Thread M	K	a	d
0–25	13	7	83	36	5	40	30	8	M5×0.8	50	39	15
25–50	25	13	98	61	5	71	14	8	M5×0.8	70	59	15
50–75	38	25	113	86	5	90	10	10	M6×1	70	59	15
75–100	51	37	150	117	8	126	9	12	M8×1.25	43	30	20

Fig. 1



Dimensions	1	2
A	280	165
B	210	125
C	110	30
D	180	95

Fig. 2

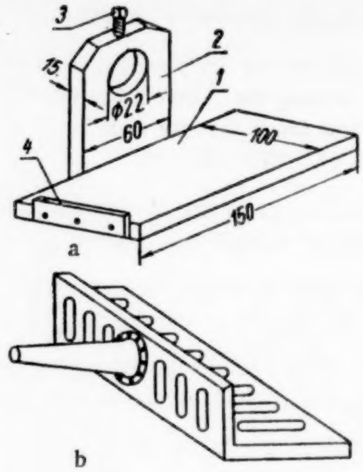


Fig. 3

For checking on the optical dividing head (ODH) articles having center holes, lugs are usually employed for turning the articles. Figure 1 shows the lugs of four different sizes which are used at the plant with articles up to 100 mm in diameter.

The height of the ODH journals and that of the tailstock is 130 mm, which limits the size of the articles which can be checked on optical dividing heads.

For measuring articles with diameters exceeding 130 mm, special stands which are placed under the ODH and the tailstock were made (Fig. 2). The stands have on their bottom surface special pins which fit into the slots of the base plate. The stands are fixed to the base plate by means of bolts.

The upper surface of the stands has slots to fit the pins of the dividing head. The head and the tailstock are in turn fixed to the stand by means of bolts. The pins and slots of the stands should, of course, be checked for parallelism with respect to the slots in the base plate. Both stands must be of the same height. Adjustment is made by means of a dial gage and a reference cylindrical spindle fixed in the ODH journals.

For measuring large details, especially those without centers, and gear wheels, various rings and washers, face plates of 150 and 400 mm in diameter are used; in the "Vulkan" plant, up to 700 mm in diameter. The face plate has a stem with a No. 4 Morse cone by means of which it is fixed in the ODH.

The axis of the shaft is perpendicular to the reference (working) surface of the face plate. In order to save weight, the face plate is either made hollow or out of aluminum alloys. It has 4-6 T-shaped slots, either perpendicular or at 60° to each other, cut in its surface. A clamp, fixed in the slots, is used for holding the details on the face plate. The detail can be checked either in the vertical or horizontal position of the ODH spindle.

Sometimes a self-centering chuck with a special extension to the measuring microscope [1] is used in the ODH.

For a speedy and accurate determination of a slope or tapering, special adjustable angle pieces are used.

Two constructions of suspended adjustable angle pieces are shown in Fig. 3.

Base 1 (Fig. 3,a) has a vertical plate, 2, rigidly fixed to it at right angles.

A short cylindrical mandrel with a No. 4 Morse cone or a journal with a cylindrical neck is inserted into the cone -shaped hole of the ODH. The suspension angle piece is fixed to the cylindrical portion of the mandrel or the cone by means of the hole cut in the vertical part of the angle piece.

When the angle piece is fixed, the ODH is placed for simplicity's sake on zero. Then the corner-piece base, 1, is placed by means of a height gage parallel to the main base plate (of the ODH) by turning manually the angle piece on the cylindrical part of the mandrel. After this adjustment the angle-piece is secured to the mandrel by means of set screw 3.

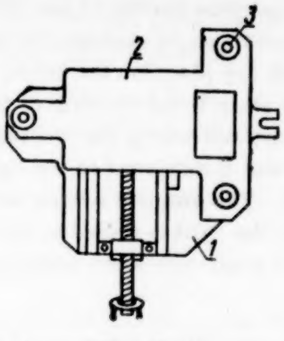


Fig. 4

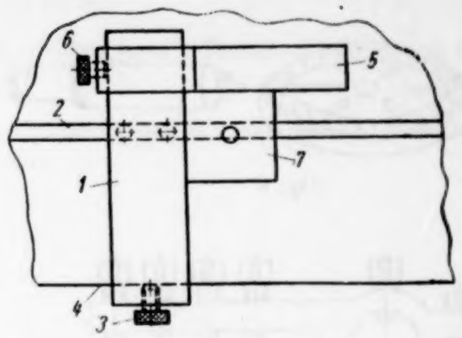


Fig. 5

The detail or the device with a slope or taper under test is then placed on base 1 parallel to its longer side. In order to prevent the detail slipping, the base has a stop plate 4.

The measurement of the slope or the taper amounts to turning the suspended angle piece with the detail, by means of the ODH mechanism, through a set angle. The angle is checked on the dial gage, and its deviation from the set value read in linear measures in this case. If it is required to measure the angle of the slope itself, the upper side of the angle should be placed so that it gives the same reading on the gage as the lower side, then the angle can be measured on the ODH scale. Tapers can be measured in a similar manner, if the cone-shaped article is placed in pointed journals mounted on the angle-piece base; and the angle, which is read-off; the ODH scale, is doubled. This angle-piece serves to measure rough slopes (group IV), with a more accurate ODH higher-grade slopes can be measured.

Figure 3,b shows an angle piece with a stem which is placed directly into the ODH hole. The adjustment of the angle piece and the method of measurement are similar to the one described above. The use of these angle pieces has speeded up and made more accurate the measurements involved.

The checking of curved surfaces of flat cams is made on the ODH by means of a horizontal distance gage, because the checking by means of the dial gage has substantial disadvantages: a large error of readings (25 μ) and a small range (10 mm). The Leningrad plant "Vulkan" [2] use two instruments simultaneously for checking cams: the optical dividing head and the optical height gage IZV-1, mounted on a common stand. For accurate centering of the two instruments along one axis, a special mounting was made (Fig. 4), consisting of a fixed base, 1, and a moving upper plate, 2. The base has two cotters on its lower surface for placing in the slots of the ODH base plate. The upper plate contains three sockets, 3, for placing the feet of the height gage. The top plate of the mounting can be moved, by means of an adjusting screw with a nut, perpendicularly to the center line of the ODH so as to be able to make this line coincide with the displacement line of the height-gage measuring rod. The height-gage bracket-mounted eyepiece can be turned through 180° round its pillar.

For measuring the angle of a helix, the pitch of a worm-gear or of a gear cutter, the ODH dial gage must be accurately set for a certain "depth", in the majority of cases for a mean diameter, or an initial circle, and simultaneously moved along the axis of the detail according to its pitch. A special square is used for this purpose and fixed in the slot or the T-shaped groove of the base plate. The square consists of plate, 1, (Fig. 5) 100 mm wide with two rollers or locating pins fixed to its bottom surface for engaging with base plate groove 2. The rollers or locating pins are perpendicular to the larger side of the plate. The plate is fixed to the ODH base by means of set screw 3, which is tightened against the side surface of base plate 4. Strip 5 can be moved along plate 1 and fixed by means of screw 6. Strip 5 is perpendicular to plate 1 and parallel to the axis of the ODH and hence to that of the detail under test. Plate 1 and strip 5 are adjusted and fixed by means of screws so that the dial-gage stand 7 (preferably of a rectangular shape) touches with its two sides plate 1 and strip 5 and, concurrently the dial-gage measuring rod is set to zero and made to touch the detail in a determined place at a determined "depth". Strip 5 will then serve as a rest providing a constant touch line when the indicator dial is displaced and the side of plate 1 will provide the initial position for measuring the pitch, i.e., for measuring the displacement of the dial gage along the axis of the detail. The displacement of the dial gage along the axis is fixed by means of block gages placed between the side of plate 1 and the dial gage stand.

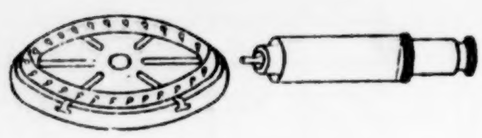


Fig. 6

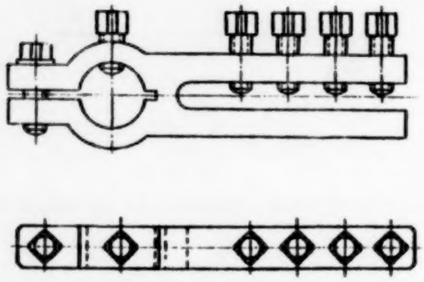


Fig. 7

For measuring the pitch angle of helix, the detail is first placed in the pointed journal of the ODH and the pitch of the helix is determined, by making the measuring rod of the dial gage touch any place on the helix, placing the dial-gage stand against plate 1 and the strip of the square, setting the gage to zero and noting the reading of the ODH scale. Next the stand is displaced to the right of the plate as far as it will go. The distance is then determined by blocks (dimension M) and the ODH is turned so that the dial gage set to dimension M reads zero when touching the rest strip of the square.

Let us denote the difference in the dividing head displacement by N, then

$$T = \frac{360°M}{N},$$

where T is the pitch of the helix, mm; M is the displacement of the dial gage, mm; N is the angle of rotation in degrees.

Having found the helix pitch we determine its angle:

$$\tan\alpha = \frac{\pi D}{T},$$

where D is the diameter of the initial circumference; T is the pitch of the helix; α is the angle of the helix.

When it is required to measure on the ODH angular dimensions of large details whose reference surfaces are either inconvenient or inaccessible to the dial gage, a measuring microscope MIR-1 on a stand is used. The detail under test is placed on a mandrel in the journals of the ODH or on a face plate in a vertical or horizontal position. If it is placed on a face plate, it is necessary to center it accurately and then fix in clamps.

This test is represented diagrammatically in Fig. 6.

The detail, a rim with special shape holes, is placed on a face plate of the ODH and the microscope MIR-1 on a stand of the base plate. The microscope eyepiece has a grid with several hairlines, one of which is placed tangentially to the side of one of the openings and the reading on the ODH scale noted, then the face plate with the detail is rotated until the next hole becomes tangential to the same hairline, the difference in the indications of the ODH scale gives the actual angle (pitch) of the spacing of the opening on the detail; this operation is repeated until all the holes have been measured. For checking the deviations of the pitch expressed in linear measures, the dividing head is set to the required angle and the deviations measured on the microscope scale. For more precise measurements the eyepiece of microscope MIR-1 is replaced with an eyepiece micrometer AM9-2. It is also convenient to use the AM9-2 eyepiece because its hairline can be set at any angle to the plane of rotation instead of remaining always perpendicular to it. The pitch of other details can be checked in a similar manner (gears, slotted rings, slit calibers, etc).

It should be noted in conclusion that the ODH cast-iron plate and its dog made by the manufacturers of the instrument, is not suitable for diverse measurements. The base plate has a T-shaped slot for fixing the ODH and the tailstock and a slanting slot, placed at the side of the T-shaped slot, for fixing the measuring devices. Such a position of the slots and the reference plate (which in addition is not completely flat, but has a dip in it), is inconvenient for measuring details simultaneously from both sides (for instance when measuring broaches). A wider base plate, 500-600 mm wide, 1.5-2 m long and completely level should be recommended with three T-shaped slots; the middle one designed for fixing the ODH and the two other slots symmetrically placed with respect to it for fixing the measuring devices.

Instead of the dog with a catch now supplied with the ODH, a better dog with set screws (Fig. 7) should be supplied.

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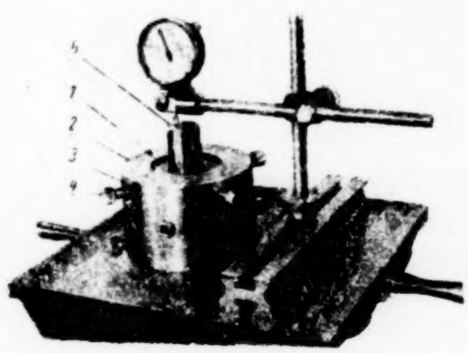
PREPARATION OF LAPS FOR THE LAPPING OF GAUGES

M. M. Mergol'd

The lapping of the measuring surfaces of worn micrometers, lever snap gauges, slide gauges and other universal measuring instruments is made by means of special cast-iron cylindrical laps in the shape of rollers, 30 mm in diameter, whose faces mut not deviate from linearity and parallelism by more than 1-2 μ.



Although the lapping of one of the measuring faces of the lap is not difficult, and can be made in batches with the simplest of equipment, the lapping of the other face becomes a more complicated operation, since in it the required parallelism of the two measuring faces is attained.

In order to simplify and speed up considerably the preparation of the second face of the lap, the use of the following equipment (see figure) is suggested.

Four threaded holes 1M8 × 1N are cut crosswise in the side and also 10-20 mm from the ends of a hollow cylinder, 1, of 33 mm internal and $65C_1$ external diameter (the height of the cylinder corresponds to that of the lap under preparation). cylinder is placed inside another cylinder, 2, with an internal diameter of $65A_1$ and external one of 120 mm and eight clearance holes, 3, on its side for the 1M8 × 1N bolts, which are screwed into the corresponding threaded holes of the first cylinder.

The cylinder thus assembled are placed on a first grade surface plate. Lap 5 under preparation is placed inside the first cylinder with its lapped side upwards and then fixed by means of bolts, 4, so that its unlapped end touches the surface plate, and the bottom end of the small cylinder is 1 mm away from the plate surface. By appropriately tightening the four top cross connected bolts 4, the top face of the lap is easily placed in a position parallel to the surface plate. The measurement is made by means of a geared-lever dial gauge which has graduations of 0.001 mm and is fixed to a universal stand. Next, the whole device with the lap firmly held by the bolts is transferred to a lapping plate and the lapping can then be carried out without any further difficulty. The floating cylinder 1 is pressed down during lapping by hand or by means of a special spring.

Above method speeds up lapping by factor of 6-8 as compared with the normal manual method and ensures a greater accuracy without high skill on the part of the operator.

* Leningrad House of Scientific and Technical Propaganda.

FLEXIBLE TEMPLETS

I. S. Vasilenko

In factory practice it is often necessary to check profiles of articles (for instance radii of curvature, angles, etc.) without the required templets and an easy way of making them. In such cases it is possible to make a templet easily and cheaply out of an old or exposed photo or x-ray film (its thickness is about 0.2 mm).

The required profile is drawn on the film by means of a scriber. Then taking the film between the fingers of both hands so that the line drawn on the film comes close between the two thumbs, the film is bent and broken round the outline of the profile, thus producing the required templet and a counter-templet. It should be noted that the film breaks easily and produces a clean break in the first bending if the depth of the drawn line amounts to 25-30 μ, i.e., when a considerable pressure is exerted on the scriber.

MECHANICAL MEASUREMENTS

EXPERIMENTAL DETERMINATION OF ERRORS IN PISTON MANOMETERS AT HIGH PRESSURES

M. K. Zhokhovskii

The theoretical errors in manometers caused by strains in the piston and cylinder were determined in [1-3] for all types of instruments. The solution of this intricate problem was obtained by making certain approximations which require experimental checking. The correction formulas were successfully confirmed experimentally by V. N. Samoilov [4] for various types of manometers for pressure up to 2500 kg/cm². In the present work the previously obtained solutions are checked experimentally over a substantially larger range.

The correction to the manometer reading [1-3] which accounts for changes in the effective area of the piston due to pressure, can be written in a general form as:

$$\Delta p = -\lambda p^2, \tag{1}$$

where p is the pressure measured by the instrument; λ is the generalized coefficient of the changes in area.

Quantity λ is expressed by means of the elastic constants of the piston and the cylinder and by their dimensions. For the piston systems used in the present work, values of λ have the form, for a simple piston in a normal cylinder,

$$\lambda = \frac{3\mu'-1}{E'} + \frac{1}{b}\left(\frac{k}{2} - k_1\right); \tag{2}$$

for a simple piston in a cylinder with counterpressure,

$$\lambda = \frac{3\mu'-1}{E'} - \frac{1}{b}\left(k_6 - \frac{k_5}{2}\right). \tag{3}$$

Here k, k_1, k_5 and k_6 are strain coefficients of piston systems:

$$k = \frac{a}{E}\left[\frac{R^2+a^2}{R^2-a^2} + \mu\right] + \frac{b}{E'}(1-\mu'); \tag{4}$$

$$k_1 = \frac{b}{E'}\mu'; \tag{5}$$

$$k_5 = \frac{a}{E}\left[\frac{R^2+a^2}{R^2-a^2} + \mu\right] + \frac{b}{E'}(1-\mu'); \tag{6}$$

$$k_6 = \frac{a}{E}\left[\frac{2R^2}{R^2-a^2} - \mu\right] + \frac{b}{E'}\mu'. \tag{7}$$

In (2-7) the following notations have been adopted: d is the internal radius of the cylinder; b is the radius of the piston; R is the external radius of the cylinder; E and E' are moduli of elasticity of the cylinder and the piston; μ and μ' are the Poisson coefficients of the cylinder and the piston.

It is known that thus far there are no manometers without strains caused by pressure changes. A direct comparison of an instrument under investigation with such a manometer is therefore impossible and only indirect

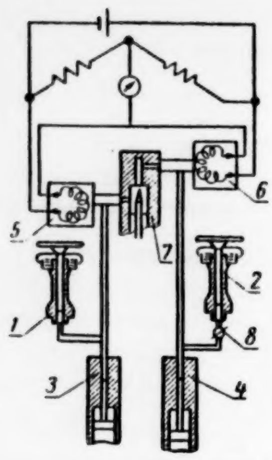


Fig. 1

methods can be used for checking (1). In this work, the method of comparing manometer readings by means of a special differential instrument is employed. This experiment determines the difference between the errors in the two instruments due to strains in their piston systems. Above errors are known for each instrument from theoretical considerations,and thus it becomes possible to compare theory with experimental data.

Figure 1 shows the schematic diagram of the equipment used. Each piston manometer, 1 and 2, is connected with its own multiplier, 3 and 4, and a manganin manometer, 5 and 6. The latter are connected through valve 7 in such a manner that with the needle of the valve in an open position the two manometers are interconnected and in the closed position they work separately, each manganin manometer being subjected to pressure provided by the piston manometers connected to them. The coils are connected in a bridge circuit in such a manner that the galvanometer reads directly the difference of their pressure, i.e., the manganin manometers form a differential instrument.

The technique of determining the difference in reading of the piston manometers being compared, amounted to the following. With valve 7 opened the required pressure is established by means of one of the piston manometers and the bridge reading noted. Next, by closing valve 7, the connection between the manganin manometers is broken and both piston manometers are brought to balance by means of their multipliers. If the pressure established by the manometers are equal, the bridge will register the same reading. If the pressures are different, owing to differences in the strains of the piston systems, the bridge reading will change and the difference in errors of the two manometers will be found from the difference in the two readings of the galvanometer.

TABLE 1

Type of cylinder	Number of the piston system	Nominal piston diameter, mm	Ratio of the external to the internal diameter $m = R/a$	Limiting pressure, kg/cm^2	Brand of steel		Calculated values of coefficient $\lambda \cdot 10^7$, cm^2/kg
					of the piston	of the cylinder	
With counterpressure	3	4	6	7000	ShKh 15	50 KhFA	−6.25
	5	3	4	7000	ShKh 15	50 KhFA	−6.43
Without counterpressure	4	4	6	5000	ShKh 15	50 KhFA	−2.75
	8	3	8	7000	ShKh 15	50 KhFA	−2.68

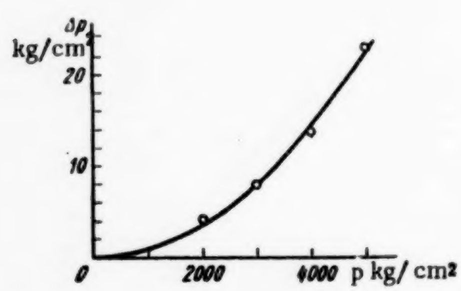


Fig. 2. Graph of Δp against pressure for piston systems No. 3 and No. 4.

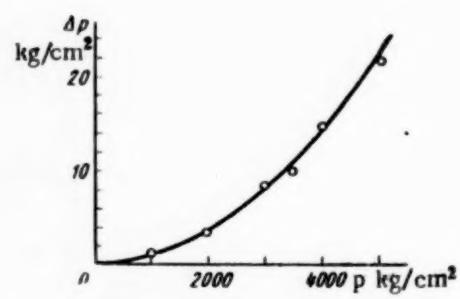


Fig. 3. Graph of Δp against pressure for piston systems No. 4 and No. 5.

Let us assume that p_1 is the nominal pressure being compared in manometers 1 and 2, and calculated without corrections for strain. Then real pressure values obtained on the resistance manometers 5 and 6 will be written as $p_1 + \Delta p_1$ and $p_1 + \Delta p_2$, where Δp_1 and Δp_2 are strain corrections. Let the changes in resistance corresponding to the real pressures be ΔR_1 and ΔR_2 and the material of the coil be the same. Then

$$\Delta R_1=(p_1+\Delta p_1)R_0\alpha,$$
$$\Delta R_2=(p_1+\Delta p_2)R_0\alpha,$$

where R_0 is the initial resistance of the manometer coils and α is the piezoelectric coefficient.

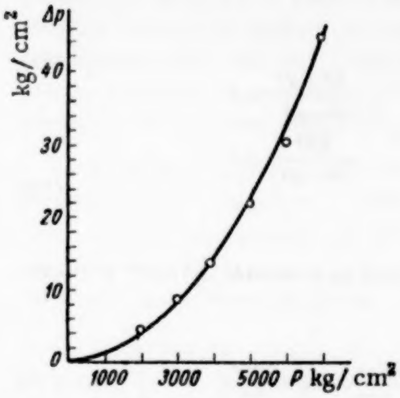


Fig. 4. Graph of Δp against pressure for piston systems No. 5 and No. 8.

The difference between the above equations is

$$\frac{\Delta R_2-\Delta R_1}{R_0\alpha}=\Delta p_2-\Delta p_1, \tag{8}$$

or

$$\Delta p=\Delta p_2-\Delta p_1, \tag{9}$$

since the left hand side of Eq. (8) is the pressure difference registered by the manganin manometer. Thus Δp expresses directly the difference between the errors of the manometers under investigation.

The value of Δp can be calculated from the experimentally obtained values of ΔR_2 and ΔR_1, if α and R_0 are known or from the calibration of the bridge. The calibration can be carried out over a small range of pressures by means of one of the piston manometers under test for each experiment separately, i.e., near the value of the pressure being investigated.

From the above it follows that equalities (8) and (9) hold if all the other errors of the manometers being compared are not taken into account.

The method can be changed to compare the corrected values of the piston manometers. In this case the instruments under test are corrected according to Eq. (1) in advance, and if they are correct $p_1 + \Delta p_1 = p_1 + \Delta p_2$, hence $\Delta R_2 = \Delta R_1$ and the bridge readings should not change.

A bridge with equal arms ($R_0 \approx 100$ ohm) and a compensating arm was used in the experiment. The circuit parameters were chosen to make one graduation of the mirror galvanometer correspond to a pressure of 0.2 kg/cm². Piston manometers and multipliers of the author's design [2] were used in the experiment and had two interchangeable piston systems: simple piston in a normal cylinder and in a cylinder with counterpressure. It is known that these systems have different values of the λ coefficient, both in magnitude and sign.

By comparing the different piston systems in various combinations, it is possible to investigate errors of manometers with similar and different types of cylinders. In the first instance the expected error differences are very small over the whole range of pressures, in the second they attain the largest values. Let us show that when comparing them it is advisable to use the same materials for the cylinders and the pistons. Under these conditions it becomes possible to eliminate the systematic errors due to the inaccuracies in the values of the elastic constants of materials.

The required difference in errors between two manometers being compared is

$$\Delta p=\Delta p_1-\Delta p_2$$

or according to Eq. (1)

$$\Delta p=(\lambda_1-\lambda_2)p^2=\Delta\lambda p^2. \tag{10}$$

TABLE 2

Nominal pressure, kg/cm²	Difference in reading of the piston systems under comparison, kg/cm²									
	No3 No 4		No 4 No 8		No 4 No 5		No 3 No 5		No 5 No 8	
	experimental	calculated	experimental	calculated	experimental	calculated	experimental	calculated	experimental	calculated
1000	0.9	0.9	0	0	—	0.92	—	0.02	—	0.9
2000	3.4	3.6	0	0.02	4.2	3.7	0	0.08	4.5	3.6
3000	8.1	8.1	−0.2	0.05	8.1	8.3	0	0.17	8.6	8.2
3500	9.9	11.0	—	—	—	11.0	—	—	—	—
4000	14.7	14.4	0	0.10	13.9	14.7	−0.5	0.30	14.4	14.6
5000	21.8	22.5	−0.2	0.15	23.1	23.0	−1.0	0.47	22.1	22.8
6000	—	—	—	—	—	—	−1.4	0.68	30.4	32.8
6500	—	—	—	—	—	—	−1.7	0.80	—	—
7000	—	—	—	—	—	—	—	—	44.8	44.6

Let us make the obvious approximation $a \simeq b$ in Eqs. (4-7) and introduce the notation:

$$\frac{R^2+a^2}{R^2-a^2}=c \tag{11}$$

and

$$\frac{2R^2}{R^2-a^2}=c'. \tag{12}$$

Then for the piston in a normal cylinder we have from (2)

$$\lambda=\frac{3\mu'-1}{2E'}+\frac{c+\mu}{2E} \tag{13}$$

and similarly for a piston working in a cylinder with counterpressure we have from (3)

$$\lambda=\frac{3\mu'-1}{2E'}+\frac{c-2c'+3\mu}{2E}. \tag{14}$$

Let us find an expression for Δp from (10) for various combinations of the piston system under comparison. Let us adopt for each instrument notations with subscripts 1 and 2. From Eqs. (13) and (14) with the same materials for the cylinders and pistons we have: for two manometers with simple pistons and normal cylinders

$$\Delta p=\frac{c_1-c_2}{2E}p^2, \tag{15}$$

for two manometers with simple pistons in cylinders with counterpressure

$$\Delta p=\left[\frac{c_1-c_2}{2E}+\frac{c_2'-c_1'}{E}\right]p^2, \tag{16}$$

for combinations consisting of a pistons in a normal cylinder and a piston in a cylinder with counterpressure

$$\Delta p=\left[\frac{c_1-c_2+2c_2'-2\mu}{2E}\right]p^2. \tag{17}$$

It will be seen from above relations that in combinations with similar cylinders expressions for Δp contain the modulus of elasticity of the cylinder and constants c_1, c_2, c_1' and c_2', depending only on the dimensions of the piston system. For combinations with unlike cylinders the value of Δp depends, in addition, on the elasticity constant μ of the second cylinder. In both combinations the elasticity constants of the pistons were excluded.

If, however, it is assumed that the materials of which the pistons and cylinders are made are not the same, the expression of Δp will contain eight different constants of elasticity. For instance, for two pistons in normal cylinders we have

$$\Delta p=\left[\frac{3\mu_1'-1}{2E_1'}+\frac{c_1+\mu_1}{2E_1}-\frac{3\mu_2'-1}{2E_2'}-\frac{c_2+\mu_2}{2E_2}\right]p^2.$$

Other systematic errors of the method (for instance, due to inaccuracies in the mass of the weights and the initial values of the piston areas) are easily eliminated by careful measurement of these quantities.

On the basis of the above method experiments were conducted with four high-pressure piston systems whose general characteristics are shown in Table 1. The elasticity constants of the materials used were not measured

and for calculating λ their values were taken from tables, making them the same for cylinders and pistons. The piston systems shown in Table 1 were compared in five different combinations. The test results thus obtained must be regarded as preliminary and are given in Table 2 and Figs. 2-4 (the full lines are calculated values and dots experimental results). These data show that experimental differences of manometer errors due to strains at pressures up to 5000 and 7000 kg/cm^2 on the whole agree well with the calculated values. As a rule the deviations are of a random nature and small, although separate points may differ considerably.

A certain reservation should be made for the experiments with piston systems which have cylinders with counterpressure (systems No. 3 and No. 5, Table 2). In this instance from 4000 kg/cm^2 there is a discrepancy between the experimental and calculated values; moreover it is in a direction opposite to the one expected, which is denoted by a minus sign. These divergencies are only small in size (of the order of 0.02-0.04%) but their systematic nature is obvious.

In examining the experimental results it should be borne in mind that the calculated value of the difference in reading of the manometers under comparison is derived from the elasticity constants of the cylinder which is taken from tables as $E = 2 \cdot 10^6$ kg/cm^2 and $\mu = 0.26$. On the basis of the previous reasoning it was assumed that by using the same material for the cylinders in all the systems the affect of the elasticity constants on the results was completely eliminated. If the latter assumption holds, the divergence between the calculated and experimental values of Δp can be due to differences in the actual and assumed values of E and μ. These differences are not expected to be large. A more precise evaluation of the results obtained requires, however, direct measurements of E and μ. This will be done in further investigations.

CONCLUSIONS

The suggested method of comparing piston manometers of high pressures by means of a differential instrument is also applicable for determining experimentally the differences between the errors as functions of pressure. The experiments carried out up to pressures of 7000 kg/cm^2 confirmed the previously obtained formulas of corrections for strains in manometers with different piston systems.

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A STANDARD PORTABLE MOMENT-METER

N. G. Tokar'

Instruction 233-56 of the Committee of Standards, Measures and Measuring Instruments specifies the checking of machines used for testing torsion in materials. The instruction specifies as a standard instrument a reference lever and a set of reference weights. The checking amounts to the comparison of the reading of the machine with the moment M applied to the machine by means of the reference lever (Fig. 1).

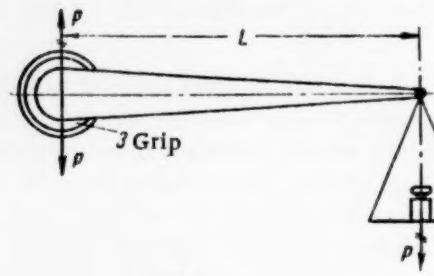

Fig. 1

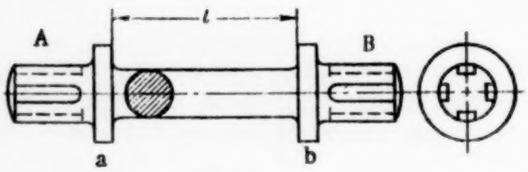

Fig. 2

The applied moment M = LP.

Theoretically, this method of checking is perfectly sound but its application in many cases is difficult for the following reasons: not only moment M is applied to the grip of the machine but also a transverse force P which represents an additional load on the bearings of the grip and is not always desirable; when checking large machines this method is labor-consuming and cumbersome; there exist machines with an arrangement of measuring devices whose operation is changed by the application of the lever and weights and requires additional measurements of the length of levers in the machine which is not always easy to accomplish and always involves dismantling the machine.

For above reasons it was found necessary to improve the method of checking machines used for testing torsion. With this object in view the author developed a portable instrument for measuring moments — a moment-meter*, based on measuring the moment by the angle of twist of an elastic-steel cylindrical shaft.

By Hooke's law we have

$$M = \frac{l\varphi}{GI_p}.$$

where M is the moment under test, kg · cm; l is the length of the shaft, cm; G is the 2nd-order modulus of elasticity of the shaft material, kg / cm^2; I_p is the polar moment of inertia of the cross-sectional area

$$I_p = \frac{\pi d^4}{32}, \text{cm}^4,$$

where d is the shaft diameter, cm; φ is the angle of twist over length l, in radians.

By knowing the values of constants l, G, and I_p and measuring angle φ, we obtain moment M. The moment-meter shaft which is an elastic body (spring) is made of tempered steel, brand 30KhGSA, and has the shape shown in Fig. 2. Ends A and B of the shaft are placed in the grips of the machine which they are made to fit. Figure 2 shows a construction with splined cylindrical ends. Collars a and b serve to fix measuring instruments and eliminate the "end effect" of the machine grips. The construction of the moment-meter is shown in Fig. 3. One of the ends of a thin-walled tube 3 is fixed by means of an universal joint, which comprises ring 2, to the left collar of shaft 1. The other (right hand side) end of the tube is suspended from the collar of the shaft by means of three special elastic guides. These guides prevent any radial displacements of the tube but allow it to rotate round the shaft within certain limits. Lever 5 is fixed to the right hand end of the tube and lever 6 to the shaft collar. A standard dial-gage 7 graduated in 0.01 mm is fixed to the end of lever 6 with its measuring rod resting against lever 5. When the torque acts in the direction shown in Fig. 3, the shaft twists through angle φ.

* A. N. Grekov participated in the constructional development of the instrument.

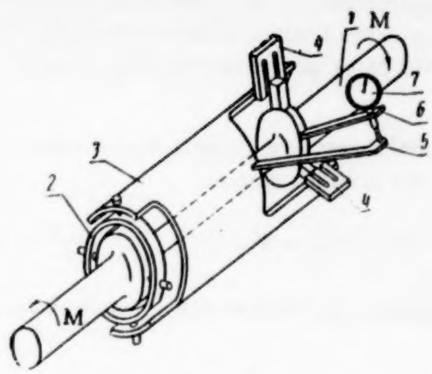

Fig. 3

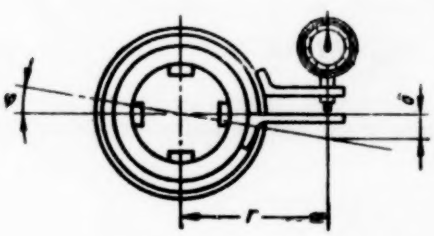

Fig. 4

The right hand side of the tube will, obviously, turn by the same angle φ with respect to the collar of shaft 1. The angular displacement of the tube with respect to the shaft causes a displacement of the dial gage 7 by the amount δ expressed by the number of divisions indicated by the dial pointer. The angle of twist φ is obtained from the dial indications δ according to expression (Fig. 4).

$$\varphi = \frac{\delta}{r \cdot 100}.$$

With the knowledge of angle φ it is possible to determine the value of the moment. In practice there is no need to determine φ, since the scale of the instrument can be calibrated directly in units measuring the moment. This can be done from the relationship

$$M = \frac{\varphi G I_p}{l} = \delta \frac{G I_p}{100 r l}.$$

Here $\frac{GI_p}{100rl}$ is a constant and, hence, the value of the moment is completely determined by the number of scale divisions. The Gor'ki State Inspection Laboratory repair and experimental shop has produced two models of a moment-meter according to the above specification: one up to 200 kg · m and the other up to 2000 kg · m.

Tests have shown that moment-meter described above helps to rationalize testing and can serve as a new standard instrument of high precision.

DYNAMICS OF A SELF-BALANCING MANOMETER FOR MEASURING LOW GAS PRESSURES

V. I. Bakhtin

The gas pressure in a self-balancing manometer distorts the shape of an elastic container (membrane of bellows) and is then automatically balanced by the ponderomotive force of the magnetic field. Figure 1 shows the diagram of a moving coil transducer of a self-compensating manometer and Fig. 2 shows its electrical block-schematic. The manometer has a range of 10^{-2} to 27 mm Hg and its error amounts to ± 3% of the measured value. The lower bellows is evacuated and sealed with a getter, which obviates the necessity of continuous pumping. The manometer represents a closed self-balancing system in which a computing device is added for recording the compensating force.

The equation of the movement of the envelope, which has an equivalent mass m, rigidity K_{en}, attenuation 2η, and an effective area S has the form

$$m\Delta \ddot{W}_o + 2\eta\Delta \dot{W}_o + K_{en}\Delta W_o = S\Delta p_x - P, \tag{1}$$

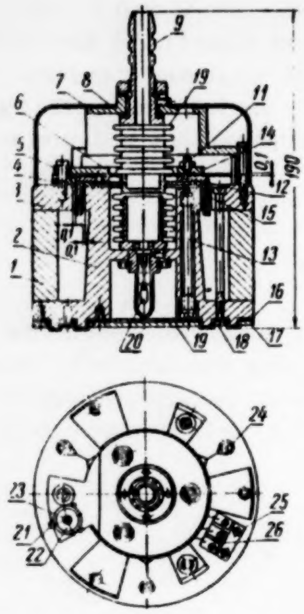

Fig. 1. 1) Magnet; 2, 3) the magnetic circuit; 4, 5) insulator; 6) connecting washer; 7) silumin bracket; 8) container; 9) nipple; 10) bellows; 11, 12 and 13) detainers; 14) electrode of the capacity transducer; 15) coil; 16) rubber; 17, 18, and 19) shock absorber details; 20) getter of the zero-chamber; 21, 22, and 23) high-frequency lead-out from the capacity transducer; 24) centering torsion suspensions; 25, 26) lead-out of the coils.

where Δp_x is the measured gas pressure difference; P is the compensating force; ΔW_0 is the displacement of the envelope (calculated from the level corresponding to the loading of the envelope by the weight of the attached details only); points denote differentiation with respect to time.

The equation of the movement of an inertia-free electronic indicator can be written in the simplest case as

$$U_{ind} = K_{ind}\Delta W_o, \tag{2}$$

where U_{ind} is the output signal of the indicator; K_{ind} is the indicator transfer constant.

Current I which flows through the compensating device winding with an ohmic resistance R and an inductance L is related to the terminal voltage by the expression

$$U_{ce} = RI + L\dot{I}.$$

The movement equation of the compensating mechanism can be written in the form

$$U_{ce} = \frac{R}{K_{cm}} P + \frac{L}{K_{cm}} \dot{P}, \tag{3}$$

where $K_{cm} = \Delta P/\Delta I$ is the transfer constant.

The indicator signal is insufficient to control the powerful compensating mechanism and required amplification. As it will be subsequently shown, owing to the substantial difference in the speed of response of the envelope, the indicator and the compensating mechanism is unstable, and it is therefore necessary to introduce a damping device which produces and attention proportional to the speed of transition of the system as a whole. The equation of the element which produces the amplification and the damping can be written as follows:

$$U_{ce} = K_{ce}\, U_{ind} + \varkappa \dot{U}_{ind} \tag{4}$$

where U_{ce} is the control-element output voltage supplied to the terminals of the compensating mechanism; K_{ce} and κ are transfer constants of the element with respect to the fundamental signal and its second derivative.

In the case of joint operation of the manometer elements, expressions (1), (2), (3) and (4) form a system of simultaneous equations:

$$\left.\begin{aligned} m\Delta\ddot{W}_o + 2\eta\Delta W_o + K_{el}\Delta W_o &= S\Delta p - P, \\ U_{ind} &= K_{ind}\Delta W_o, \\ U_{ce} &= K_{ce}\, U_{ind} + \varkappa U_{ind} \\ U_{ce} &= \frac{R}{K_{cm}} P + \frac{L}{K_{cm}} \dot{P}, \end{aligned}\right\} \tag{5}$$

which provides, when the intermediate coordinates are excluded, an equation of the movement of a closed self-balancing system in terms of Δp and ΔW_0 coordinates:

$$\Delta W_o + p_1\Delta\ddot{W}_o + p_2\Delta\dot{W}_o + p_3\Delta W_o = p_4\Delta p + p_5\Delta p. \tag{6}$$

Here

$$p_1=\frac{R}{L}+\frac{2\eta}{m};\quad p_2=\frac{RK_{en}}{Lm}\left(\frac{L}{R}+\frac{2\eta}{K_{en}}+K'\right);$$

$$p_3=\frac{RK_{en}}{Lm}(1+K);\quad p_4=\frac{SR}{Lm};\quad p_5=\frac{S}{m}.$$

Coefficients

$$K=\frac{K_{ind}K_{ce}K_{cm}}{RK_{en}};\quad K'=\frac{K_{ind}\varkappa K_{cm}}{RK_{en}}$$

are the basic characteristics of the system; the first one determines the constant error of self-balancing and the second, the degree of stability of the closed system.

In order to solve (6), let us assume that in short intervals of time the pressure varies linearly:

$$\Delta p = \alpha t$$

The conditions with constant α (see [1]) is most often encountered in practice and is of the greatest interest. The solution of the equation in this case will be

$$\Delta W_o=\sum_{i=1}^{3}C_i l^{\gamma_i t}+\frac{p_4}{p_3}\alpha t+\frac{\alpha}{p_3}\left(p_5-\frac{p_2}{p_3}p_4\right). \tag{7}$$

Constants C_i are determined from the initial conditions and γ_i are given by the relationships

$$\gamma_1=(U+V)-\frac{p_1}{3};\qquad \gamma_{2,3}=-\frac{1}{2}(U+V)-\frac{p_1}{3}\pm\frac{\sqrt{3}}{2}(U-V)j,$$

where

$$U;\ V=\sqrt[3]{-\frac{p_1^3}{27}+\frac{p_1p_2}{6}-\frac{p_3}{2}\pm\sqrt{\left(\frac{p_1^3}{27}-\frac{p_1p_2}{6}+\frac{p_3}{2}\right)^2+\left(\frac{3p_2-p_1^2}{9}\right)^3}}.$$

For measuring low pressures it is advisable to have a minimum lag in the self-balancing process. This will take place with a minimum value of quantities.

$$\frac{1}{p_3}\left(p_5-\frac{p_2p_5}{p_3}\right)=\frac{S}{K_{en}(1+K)}\cdot\frac{K\frac{L}{R}-\frac{2\eta}{K_{en}}-K'}{1+K}.$$

For

$$K\frac{L}{R}-\frac{2\eta}{K_{en}}-K'=0$$

self-balancing occurs without lagging at any finite speed of variations of the measured pressure. For

$$K\frac{L}{R}-\frac{2\eta}{K_{en}}-K'<0$$

overcompensation occurs in the sense of a lead.

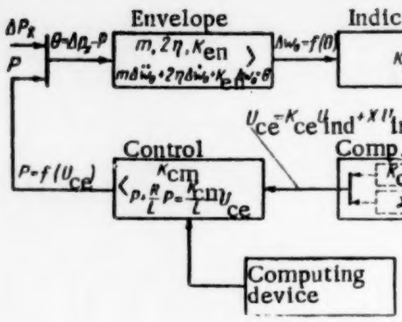

Fig. 2.

The inertia error of self-balancing is represented by systematic lagging of the compensating force behind pressure, which changes with a constant speed and also by the intensity and duration of transient processes when the gas pressure changes with an acceleration distinct from zero. The dynamic characteristics of the manometer depend on the constructional parameters (m, 2η, L, R, K_{ind}, K_{ce}, K_{cm} and κ). Moreover, a decrease of the dynamic error in the conditions of stable tracking involves a rise in intensity and duration of the transient processes, i.e., a rise in the transient dynamic error. The problem of finding optimum values for the parameters is reduced to finding K', since a part of the parameters (m, 2η, K_{en}) is set by the available elastic elements produced commercially and another part (l, R, K_{ind}, K_{ce} and K_{cm}) is determined by the aim of obtaining a maximum transfer constant of the open self-balancing circuits, i.e., a minimum static error in self-balancing. Whereas K' only determines the margin of the system's stability.

According to Hurwitz it is necessary and sufficient in order to attain a stable movement of a third order system that

$$P_i>0;\ p_1p_2-p_0p_3>0$$

or

$$\begin{cases} 1^\circ & \dfrac{2\eta}{m}+\dfrac{R}{L}>0, \\ 2^\circ & \dfrac{RK_{en}}{Lm}\left(K'+\dfrac{L}{R}+\dfrac{2\eta}{K_{en}}\right)>0, \\ 3^\circ & \dfrac{RK_{en}}{Lm}(K+1)>0, \\ 4^\circ & \left(\dfrac{2\eta}{m}+\dfrac{R}{L}\right)\left(K'+\dfrac{L}{R}+\dfrac{2\eta}{K_{en}}\right)\dfrac{RK_{en}}{Lm}-(K+1)\dfrac{RK_{en}}{Lm}>0. \end{cases}$$

For an actual self-balancing manometer, conditions 1° and 3° are always fulfilled. Conditions 2° and 4° must be satisfied. Conditions 2° is satisfied if $K'>0$, i.e.. if the signs of L/K, $2\eta/K_{en}$; κ and K coincide. It can also be satisfied with a negative K' if

$$|K'|<\frac{L}{R}+\frac{2\eta}{K_{en}}.$$

Condition 4° requires that

$$|K'|+\frac{L}{R}+\frac{2\eta}{K_{en}}>\frac{K+1}{\dfrac{2\eta}{m}+\dfrac{R}{L}};$$

this is equivalent to the requirement of a small absolute value of κ; if it is negative it can only occur with a very large K. Requirement 4° can be roughly written as

$$\frac{\varkappa}{K_{ce}}>1.$$

Let us now determine the necessary and sufficient value of the transfer constant K. It will be seen from (7) that for a given self-balancing system the displacement of the envelope corresponding to a known value of

pressure is

$$\Delta W_{const} = \frac{p_4}{p_3}\Delta p.$$

This value multiplied by the rigidity of the envelope provides the portion of gas pressure compensated by the elastic forces of the envelope, i.e., the constant error of static self-balancing. By substituting instead of p_3 and p_4 their values we obtain

$$\theta_{const} = K_{en}\Delta W_{const.} = \frac{S\Delta p}{1+K}. \tag{8}$$

Owing to irreversible processes, there appear in the material and in the contour of the envelope discrepancies between the loading and unloading elasticity characteristic curves. The discrepancy is proportional in the first approximation to the maximum deformation of the envelope:

$$\delta\Delta W_o = \frac{a}{100}\Delta W_{o\ max}. \tag{9}$$

The coefficient of proportionality α is equal for the best membranes to 0.03% and for bellows to 8-12%. Hence, the envelope movement, i.e. the constant compensation error should be limited. By substituting (9) in (8) we have

$$\delta\theta_{const} = K_{en}\Delta W_{o const} = \frac{aS}{(1+K)\cdot 100}\Delta p_{max}$$

If the minimum value of the measured pressure is Δp_{min} we have

$$\theta_{const\ max} \leq S\Delta p_{min}.$$

Hence

$$\frac{aS}{100(1+K)}\Delta p_{max} < S\Delta p_{min}$$

And the required

$$K > \frac{a}{100}\left[\frac{\Delta p_{max}}{\Delta p_{min}} - 1\right].$$

For instance, for $\Delta p_{max} = 100$ mm Hg and $\Delta p_{min} = 10^{-3}$ mm Hg, it is necessary and sufficient to have for a bellows instrument (α = 10%)

$$K \simeq \frac{10}{100}\cdot\frac{100}{10^{-3}} = 10^4.$$

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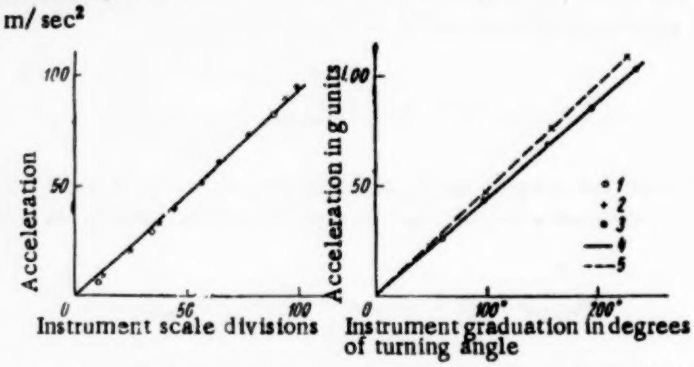
STATIC CALIBRATION OF ACCELEROMETERS AND ACCELEROGRAPHS BY MEANS OF A CENTRIFUGAL DEVICE

F. A. Markhevka

Accelerometers are calibrated statically either by applying a known effort to the mass of the sensitive element, which simulates the effect of forces of inertia, or by supplying the instrument with a known acceleration.

In the range of accelerations of 0 to g the accelerometers are checked by rotating them through a given angle about their horizontal axes. For accelerations exceeding g the sensitive-element flywheel is usually loaded with weights which are multiples of its weight. The calibration of accelerometers by this method is simple and does not require any special equipment.



1) By means of centripetal acceleration (differential method); 2) loading method; 3) by means of centripetal acceleration (ordinary method); 4) method of loading with multiple loads; 5) by means of centripetal acceleration.

The results obtained by the last method can, however, be affected by a systematic error due to an incorrect determination of the effective value of the accelerometer-flywheel mass.

Moreover, it is not always possible to mechanically secure the additional weights to the flywheel.

If the accelerometer is checked by imparting to it a known acceleration it is not necessary to determine the mass of the flywheel.

It is most convenient in this instance to use the centripetal acceleration, which is determined from the angular velocity and the radius of gyration.

The centripetal acceleration, acting in the instrument under test is calculated from the formula

$$a = \omega^2 R = 4\pi^2 n^2 R = \frac{4\pi^2 R}{T^2}, \qquad (1)$$

where ω is the angular velocity; n is the number of rpm; T is the period of one revolution; R is the distance from the axis of rotation to the center of gyration of the sensitive element of the instrument under test.

The relative error in determining the centripetal acceleration ($\delta a / a$) due to random errors in direct measurements of R and T is determined from

$$\frac{\delta a}{a} = \pm \sqrt{\left|\frac{2\delta T}{T}\right|^2 + \left|\frac{\delta R}{R}\right|^2}. \qquad (2)$$

In determining the centripetal acceleration both systematic and random errors can be made.

The physically inaccessible position of the center of inertia of the sensitive element and the displacement of the flywheel under the effect of the force of inertia may cause systematic errors in measuring R. In many instances, this error may considerably exceed the random error δR.

In order to eliminate the systematic error in the value of R it is convenient to use the differential method of testing accelerometers [1] proposed by P. N. Agaletskii. This method consists in imparting twice to the instrument under test, the same centripetal acceleration but with varying angular velocities and distances of the instrument's centers of inertia from the axis of rotation. Moreover, it is not the values of R_1 and R_2 that are measured, but the value of the radial displacement of the instrument $\Delta R = R_1 - R_2$.

In fact the value of the centripetal acceleration is found from (3) by inserting into it the results of direct measurements:

$$a = \frac{\omega_1^2 \omega_2^2 \Delta R}{\omega_2^2 - \omega_1^2} = \frac{4\pi^2 \Delta R}{T_1^2 - T_2^2}, \tag{3}$$

where ΔR is the radial distance between the first and second position of the instrument under test; T_1 and T_2 are the periods of rotation in the first and second condition of instrument testing.

The relative error of the measured value of the centripetal acceleration ($\delta a/a$) is determined in terms of the random errors of direct measurements by the equation

$$\frac{\delta a}{a} = \pm \sqrt{\left|\frac{2}{1-K^2} \cdot \frac{\delta T_1}{T_1}\right|^2 + \left|\frac{2}{\frac{1}{K^2}-1} \cdot \frac{\delta T_2}{T_2}\right|^2 + \left|\frac{\delta \Delta R}{\Delta R}\right|^2}, \tag{4}$$

where $K = T_2/T_1$.

The centrifugal measuring equipment used in the experiments consists of a welded frame inside which a vertical axle rotates on ball bearings. In order to ensure a smooth variation of the axle's angular velocity up to 4 rps, it is driven by means of a four-speed gear-box from a dc 1 kw motor with a nominal speed of 2000 rpm. The supply source consists of a 220 v storage battery.

The vertical axle is fixed to a horizonatal rod along which carriages can be displaced on either side of the axle: one for the instrument under test and the other for the counterweight (up to 6 kg).

The position of the carriage or the radial displacement of the instrument ΔR is measured by a ruler fixed to the rod and the vernier graduation of the carriage. The error of measurement is ± 0.05 mm.

The value of T was measured by recording chronograph 21P with an absolute error of ± 0.002 seconds.

The centrifugal equipment was designed to produce accelerations up to 15 g. The error in determining the actual value of acceleration in checking the accelerometers on the centrifugal equipment did not exceed in our experiments ± (1-3)%.

The largest accelerometers of the contact type, designed to measure maximum accelerations of vibrations in transport, were checked and calibrated by this means.

The figure shows calibration curves of maximum accelerometers AM(a) and GBM-200(b) obtained by various means.

The systematic difference in the GBM-200 accelerometer calibration curves was obtained by loading the armature with multiple weights and by centripetal-acceleration measurements; for the same scale divisions of the instrument the values of acceleration, obtained by means of the centrifugal equipment were larger than the corresponding values obtained by a loading method. This discrepancy is explained by the fact that in the static calibration of the accelerometer by means of weights multiple in value to the mass of the flywheel m, a systematic error was made in determining the equivalent mass of the instrument's sensitive element.

The actual value of the equivalent mass of the GBM-200 accelerometer's sensitive element is expressed by the formula

$$m' = \frac{gkm}{a}. \tag{5}$$

where $\underline{m}$ is the nominal value of the sensitive-element equivalent mass; $\underline{k}$ is the coefficient of proportionality; $\underline{g}$ is the acceleration due to gravity; $\underline{a}$ is the acceleration in g units obtained from the equipment.

Thus, by checking the accelerometer on centrifugal equipment it was possible to find the value of the systematic error made in determining the flywheel mass of the instrument and to discover a systematic error in the calibration curve of the accelerometer obtained by the method of loading the sensitive element.

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IMPROVEMENT OF THE MP-2,5 EQUIPMENT

N. I. Rusalovich

Equipment MP-2,5, designed by V. N. Gramenitskii, is sound in principle, very accurate, and essential for checking purposes, yet it is used far less than it should be, owing to the unfortunate constructional design of its auxiliary part.

In order to attain the top pressure of 2.5 kg/cm² in simultaneous checking of two standard spring pressure gauges, the person operating the equipment must operate manually the air pump at least 10 times up and down (intake and compression of air), and turn the air piston screw through at least 600 revolutions at a pressure of 1-3 kg by means of a hand-operated handle. In order to avoid these difficulties the Minsk State Inspection Laboratory for Measuring Equipment has introduced a very simple but effective additional device which, does not interfere with basic design or the advantages of the equipment, does not require any supplementary apparatus, and can be made by any State Inspection Laboratory in 3-4 hours. It consists essentially of the following.

The outlet valve opening of the right-hand-side connecting pipe is sealed off by soldering. The upper hole of the same connecting pipe is drilled out to a 6 mm diameter and a depth of 3 mm, and a brass tube 40 mm long inserted into the hole at an angle to the valve. The tube is soldered to the pipe and connected by means of rubber tubing to a Komovskii pump. Thus, by turning the valve through 180° Komovskii's pump is connected through the tubing and the right-hand-side pipe to the entire equipment for the purpose of establishing preliminary pressure. Having closed the valve it is possible to disconnect the pump and complete the smooth regulation of pressure by means of the hand air pump.

In order to remove the oil which accumulated in the oil trap of the right-hand-side connecting pipe, the valve has to be unscrewed.

A stopwatch check of modernized equipment showed that the top pressure (of 2.5 kg/cm²) is attained in 0.5 minutes, when the pump is motor-operated and in 1 minute when the pumping is done by hand. The work of the equipment has now become more productive and the time spent on testing has been reduced to one fifth of its former duration. Any other pumping equipment (for instance a compressor, or a compressed air cylinder) can be used instead of the Komovskii pump.

MEASUREMENTS OF MASS

A DEVICE FOR THE REMOTE CONTROL OF DIAL SCALES

V. Ya. Kozhukh and N. P. Onishchenko

Before a given load of coke is tipped into a blast furnace it is weighed on a hopper placed on a five-ton scale platform (the weighing hopper VK5-RG of the Starostin plant [1]). The scale's connecting rods are taken to a platform over the skip pit and joined to a spring dial. The indicating dial has mercury contacts which stop the screening machine when the weight of coke in the hopper approaches the required value and provide the pulse for closing the hopper when it is completely emptied and the pointer returns to zero.

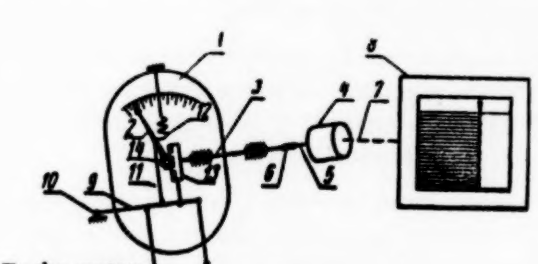

Fig. 1. 1) Dial indicator; 2) pointer; 3) pointer spindle; 4) synchrotransmitter; 5) axle of the synchrotransmitter; 6) rubber coupling; 7) cable connection; 8) displacement recorder; 9) lever; 10) hinge; 11) pull rod; 12) spring; 13) rack; 14) gear.

The required load is selected mechanically by setting the mercury contact on the dial. The operator (foreman) of the oven cannot control the operation of the coke scale continuously, since he is at a considerable distance and the scale does not provide a record of its loads.

For recording the displacements of the dial pointer and remote control of the coke scale, the authors have developed the following system based on the use of an automatic bridge circuit type MSR1 and selsyns type BD-404A and BS-404A. A simplified kinematic diagram of the device for weighing coke is shown in Fig. 1. The synchrotransmitter is placed on the dial head of the scale.

The axle of the synchrotransmitter is connected mechanically with that of the scale pointer. The recording instrument, whose general appearance is given in Fig. 2, is mounted on the main control panel of the blast furnace and connected by means of a cable to the synchrotransmitter.

A schematic of the servosystem is given in Fig. 3. The selsyns work in a transformer condition . The synchrotransmitter ST stator winding C_1C_2 is fed from the output transformer of an electron amplifier A at a voltage of 6.3 v. Such an operating condition of the synchrotransmitter reduces the braking moment of its axle practically to zero and does not lower the accuracy of the scale. The synchrorepeater SR is incorporated in the automatic bridge and its stator winding is connected to the input of the amplifier. When a difference angle arises between the positions of the ST and SR axles and emf is produced in the SR stator winding which is amplified by amplifier A and operates the reversible motor M; the latter turns the SR axle in the direction which eliminates the angular difference. At the same time motor M moves the recording and the indicating pointers of the instrument.

Such a construction eliminates the defects of certain servosystems [2]:

a) the system is insensitive to frequency variations of the supply source and provides a stable operation at the commercial frequency of 50 cps;

b) additional correcting networks at the input of amplifier are not required;

c) the moment of resistance at the synchrotransmitter axle is reduced to the friction moment of the unloaded rotor;

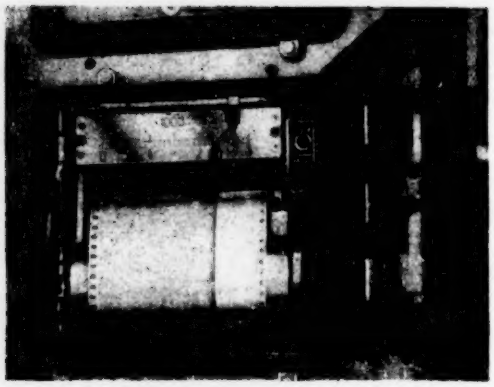

Fig. 2

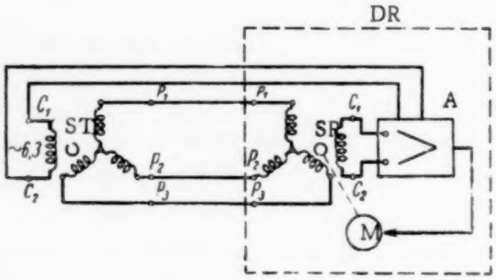

Fig. 3

d) industrially produced units are being used.

Correlation between the measured variable and the recording device is maintained by the kinematic transmission from the reversible motor to the synchrorepeater. Thus, a full swing of the recorder of a five-ton scale corresponds to 2.8 tons, which under the conditions discussed correspond in fact to the maximum load of coke. In the described recorder the connection between the reversible motor and the axle of the synrchorepeater is accomplished by means of gears. By changing the gear ratio the required limits of measurement are obtained.

A rigid transmission between the above axles is not the only possible. In instruments ÉPP-09 and ÉPP-120 (with a chart and disc diagram) the connection between the axle of the reversible motor and that of the synchrorepeater is accomplished by means of flexible transmission. The range of the scale is then adjusted by diameters of the pulleys on the motor and synchrorepeater axles.

The displacement recorder (DR) can be made out of any commercial electronic recording instrument ÉM, MS, ÉP and PS [3] by discarding their measuring circuit and carrying out the alterations described above.

Automatic control and remote setting of the required load is accomplished by means of the two-position controlling device of instrument MSR-1.

The technical conditions set by Gipromez * specify the accuracy of measurement of coke within the limits of ± 20 kg of the set value. An extended use of two recorders at one of the blast furnaces of the "Azovstal" plant showed that these instruments satisfy above requirements both for accuracy of recording and control. The synchrotransmitters have been working for a year in a very dusty atmosphere without any attention or replacement.

The displacement recorder is simple to construct and does not require skilled servicing.

Above instruments can be used not only for recording and remote control of loads on dial scales, but also for measuring and recording other quantities whose variations can be expressed in angular displacements.

K. G. Karimov, A. V. Dorokhin and Yu. V. Dokachev took part in the production and installation of the device.

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* Gipromez = State Institute for the Design and Planning of Metallurgical Plants.

AUTOMATION OF CARTESIAN-COORDINATE AC COMPENSATORS

A. M. Melik-Shakhnazarov

Automatic rectangular Cartesian-coordinate ac compensators are designed for use with various automatic and recording, checking and control devices, including the automatic measurement of error in the transformation ratio and angle of instrument transformers, the measuring and recording of complex components of impedances in automatic control, telemetering, computer and other circuits [1, 2, 3].

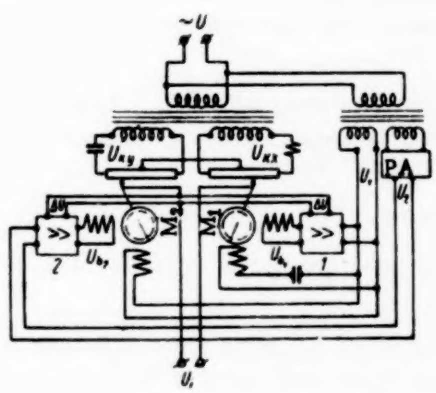

Fig. 1

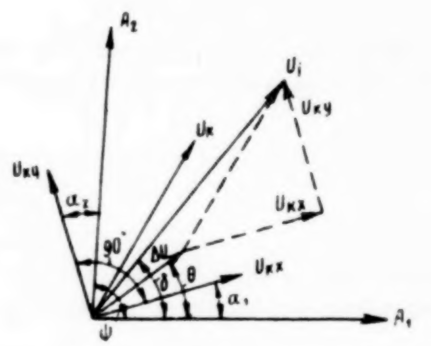

Fig. 2

Automatic rectangular-coordinate compensators can be constructed on the principle of an astatic or static tracking system [3].

In the present article the operation of an automatic compensator of the first kind is analyzed.

Some work on the automation of rectangular-coordinate compensators has been carried out in the past, but the development of the means of automation in recent years now affords the possibility of accomplishing the automation of rectangular-coordinate compensators by better methods and of using mass produced units and elements.

The schematic of such an automatic compensator developed in the Department of Electrical Measurements and Automatic Devices of the Azerbaidzhan Industrial Institute, is shown in Fig. 1.

It will be seen from the circuit that voltage U_i under test is balanced by two compensating voltages U_{kx} and U_{ky} displaced by 90°. The resulting compensating voltage is

$$\dot{U}_k = \dot{U}_{kx} + \dot{U}_{ky}. \qquad (1)$$

The difference voltage $\Delta\dot{U} = \dot{U}_i - \dot{U}_k$ is applied to the phase-sensitive amplifiers 1, 2; Two-phase induction motors M_1 and M_2 are used as actuating elements.

Since in the above case both the amplifier and the motor are phase-sensitive, the total phase sensitivity of the input voltage for the unit consisting of the amplifier and the motor will be determined both by the phase of the amplifier controlling voltage and the parameters of the motor. The speed of the motor attains its maximum at a definite phase of the amplifier input voltage.

For convenience in analyzing the operation of the automatic compensator let us assume that the phase of the input voltage corresponds to that of a certain nominal vector $\dot{A}$, which determines the phase sensitivity of the amplifier – motor unit. Moreover, the actuating motors operate on definite components of voltage $\Delta\dot{U}$, coinciding in phase with vectors $\dot{A}_1$ and $\dot{A}_2$ which represent the phase sensitivity of corresponding units.

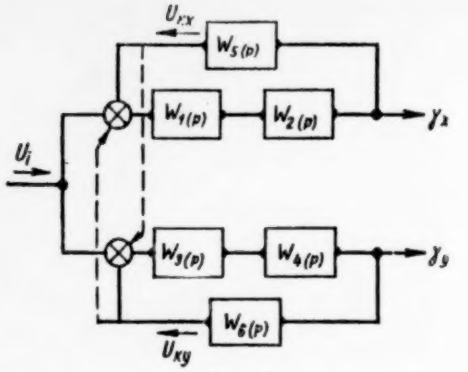

Fig. 3

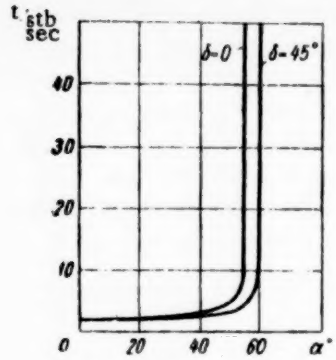

Fig. 4

If the phases of vectors $\dot{A}_1$, $\dot{U}_{kx}$ and $\dot{A}_2$, $\dot{U}_{ky}$ completely coincide, the rectangular-coordinate compensator can be represented as two completely separate compensators without any interdependence.

In producing automatic compensators, the above condition cannot always be realized, since it requires the use of fairly complicated phase shifting devices which must be readjusted if the amplitude or frequency of the supply voltage are changed.

In order to investigate the effect of the phase differences between the vectors $\dot{A}_1$ and $\dot{U}_{kx}$, $\dot{A}_2$ and $\dot{U}_{ky}$ on the operation of the automatic compensator, let us examine the general case when the above vectors do not coincide in phase.

The vector diagram of the compensator for this case is shown in Fig. 2.

It will be seen from the diagram that vector $\dot{A}_1$ is displaced with respect to $\dot{U}_{kx}$ by angles α_1, and vector $\dot{A}_2$ with respect to $\dot{U}_{ky}$ by α_2.

The compensating voltages $\dot{U}_{kx}$ and $\dot{U}_{ky}$ have a phase difference of 90° (a precise phase difference between the compensating voltages is essential; it can easily be achieved owing to the small power in the compensating circuits).

When phase differences α_1 and α_2 are present, each compensating voltage affects both actuating motors, i.e., there exists interrelation between the compensating circuits.

In phase-sensitivity manually operated, rectangular-coordinate compensators, this interdependence of the compensating circuits leads to balance by consecutive approximations, the number n of such operations required to balance the circuit being determined from the formula [4]:

$$n = \frac{\lg \sin(\delta+\alpha) - \lg\beta}{2 \lg \operatorname{ctg} \alpha}, \tag{2}$$

where β is the permissible error of measurement; δ is the angle between the voltage vector $\dot{U}_i$ under test and vector $\dot{A}_1$; $\alpha = \alpha_1 = \alpha_2$ is the phase-difference between the compensating voltage and vectors $\dot{A}_1$ and $\dot{A}_2$.

It will be seen from (2) that the number of operations required to balance the circuit increases with angle α and for α > 45° the system becomes diverging.

In an automatic compensator the balancing proceeds in a different way, owing to the simultaneous compensation of voltages $\dot{U}_{kx}$ and $\dot{U}_{ky}$.

The block schematic of the automatic rectangular-coordinate compensator is given in Fig. 3. The two compensating elements are interconnected by means of an additional feedback (shown in dotted lines). Voltage $\Delta\dot{U}$ is fed to the input of the amplifiers:

$$\Delta\dot{U} = \dot{U}_i - \dot{U}_{kx} - \dot{U}_{ky}. \tag{3}$$

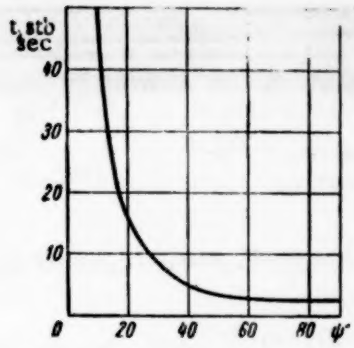

Fig. 5

Motor M_1 is operated by the voltage component

$$\delta U_x = \Delta U \cos\theta,$$

and motor M_2 by voltage

$$\delta U_y = \Delta U \cos(\psi - \theta).$$

Let us examine the transfer function of the various elements of the system. The transfer function of the first two links is

$$W_{1:2(P)} = W_{1(P)} W_{2(P)} = \frac{\bar{\gamma}_x}{\delta \bar{U}_x} = \frac{k_1 k_2}{P(T_1 P + 1)} = \frac{k_3}{P(T_1 P + 1)}, \tag{4}$$

where k_1 is the gain of the amplifier; k_2 is the characteristic coefficient of the motor and the reduction gear; T_1 is time constant of the motor; P is the operator; $\bar{\gamma}x$ is image of the motor output axle angle of rotation; $\delta \bar{U}_x$ is image of voltage δU_x.

The compensating voltage U_{kx} and the angle of rotation are related by expression

$$W_{5(P)} = \frac{\bar{U}_{\kappa x}}{\bar{\gamma}_x} = k_4. \tag{5}$$

Since it can be assumed that the parameters of both motors and amplifiers are the same, we have

$$W_{3:4(P)} = W_{3(P)} W_{4(P)} = \frac{\bar{\gamma}_y}{\delta \bar{U}_y} = \frac{k_3}{P(T_1 P + 1)}; \tag{6}$$

$$W_{6(P)} = \frac{\bar{U}_{\kappa y}}{\bar{\gamma}_y} = k_4. \tag{7}$$

From (4), (5), (6), and (7) we obtain

$$\bar{U}_{\kappa x} = k_4 \bar{\gamma}_x = \frac{k_3 k_4 \delta \bar{U}_x}{P(T_1 P + 1)}; \tag{8}$$

$$\bar{U}_{\kappa y} = k_4 \bar{\gamma}_y = \frac{k_3 k_4 \delta \bar{U}_y}{P(T_1 P + 1)}. \tag{9}$$

Fig. 6

It will be seen from the vector diagram that

$$\delta U_x = U_i\cos\delta - U_{kx}\cos\alpha_1 - U_{ky}\cos(90^\circ+\alpha_1); \tag{10}$$

$$\delta U_y = U_i\cos(\psi-\delta) - U_{kx}\cos(\psi-\alpha_1) - U_{ky}\cos\alpha_2. \tag{11}$$

Since δ, ψ, α_1 and α_2 do not change during balancing we shall consider them as constants. Moreover, expressions (10) and (11) will hold according to the addition theorem for voltage images as well.

From (8), (9), (10) and (11) (for voltage images) we obtain expressions which determine the interrelation between the measured voltage $\bar{U}_i$ and the compensating voltages $\bar{U}_{kx}$ and $\bar{U}_{ky}$:

$$\bar{U}_{kx} = \frac{k_3k_4(\bar{U}_i\cos\delta + \bar{U}_{ky}\sin\alpha_1)}{P(T_1P+1)+k_3k_4\cos\alpha_1}; \tag{12}$$

$$\bar{U}_{ky} = \frac{k_3k_4[\bar{U}_i\cos(\psi-\delta) - \bar{U}_{kx}\cos(\psi-\alpha_1)]}{P(T_1P+1)+k_3k_4\cos\alpha_2} \tag{13}$$

From (12) and (13) we determine, after the required transformations, the transfer function of the closed system taking U_{kx} as the output parameter:

$$\frac{\bar{U}_{kx}}{\bar{U}_i} = \frac{Pk_3k_4(T_1P+1)\cos\delta + k_3^2k_4^2\sin\psi\cos(\delta-\alpha_1)}{P^2(T_1P+1)^2 + k_3k_4P(T_1P+1)(\cos\alpha_1+\cos\alpha_2) + k_3^2k_4^2\sin\psi} \tag{14}$$

Similarly we can obtain the relation between U_{ky} and U_i. From (14) we obtain the characteristic equation of a closed-loop system reduced it to the form

$$\lambda^4T_1^2 + \lambda^3 2T_1 + \lambda^2[1+T_1k_3k_4(\cos\alpha_1+\cos\alpha_2)] + \lambda k_3k_4(\cos\alpha_1 + \cos\alpha_2) + k_3^2k_4^2\sin\psi = 0. \tag{15}$$

Applying Hurwitz criterion we find the condition for the system's stable operation:

$$\sin\psi > 0, \tag{16}$$

$$(\cos\alpha_1+\cos\alpha_2) > 0, \tag{17}$$

$$2T_1k_3k_4(\cos\alpha_1+\cos\alpha_2) + T_1^2k_3^2k_4^2(\cos\alpha_1+\cos\alpha_2)^2 - 4T_1^2k_3^2k_4^2\sin\psi > 0. \tag{18}$$

In order to verify the relation thus obtained we constructed an automatic compensator circuit (Fig. 1) in which automatic bridge ac amplifiers, type MS, were used as phase-sensitive elements and induction motors type RD-09 for the drive. The relation between the stabilization time of the system and angle α was established experimentally (tests were made with $\alpha_1 = \alpha_2 = \alpha$) With $\alpha_1 = \alpha_2 = \alpha$ formula (8) assumes the form:

$$\cos\alpha + T_1k_3k_4\cos^2\alpha - T_1k_3k_4 > 0. \tag{19}$$

It follows from (19) that for $k_3k_4 = 10$ and $T_1 = 0.1$ seconds, the system remains stable at $\alpha < 50°$, for a higher α it becomes unstable.

It will be seen from the experimental curve in Fig. 4 that for $\alpha < 50°$ the stabilization time is relatively independent of angle α, however, t_{stb} rises rapidly and at $\alpha > 50°$, the system becomes unstable.

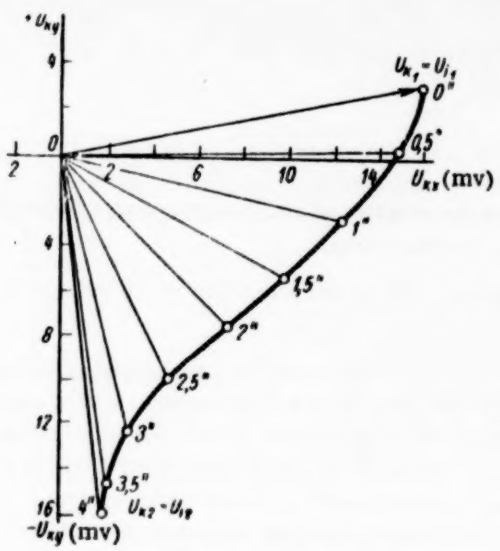

Fig. 7

Thus, the theoretical data is in good agreement with the experimental results and shows that an exact coincidence of the phases of vectors $\dot{U}_{kx}$ and $\dot{A}_1$; $\dot{U}_{ky}$ and $\dot{A}_2$ is not essential. The problem of keeping vectors $\dot{A}_1$ and $\dot{A}_2$ at right angles to each other is also of interest.

It will be seen from (16) that the stability of the system is not disturbed when angle ψ is varied within wide limits.

Experimental verification of the automatic compensator operation confirms these data. The stabilization time of the system depends only to a small extent on angle ψ (Fig. 5). Only at $\psi < 20°$, t_{stb} begins to rise rapidly and at $\psi \to 0$, $t_{stb} \to \infty$. Thus, the angle between vectors $\dot{A}_1$ and $\dot{A}_2$ can vary within wide limits without affecting the operation of the device.

Above data show that a strict coincidence of the phase of vectors $\dot{U}_{kx}$, $\dot{A}_1$ and $\dot{U}_{ky}$, $\dot{A}_2$ and an accurate 90° phase difference between vectors $\dot{A}_1$ and $\dot{A}_2$ is not essential, and the phase-shifting devices in the amplifier and motor circuits can, therefore, be fairly simple without requiring adjustment when the frequency or amplitude of the supply voltage are changed.

The presence of phase shifts α_1 and α_2 and the nonperpendicularity of vectors $\dot{A}_1$ and $\dot{A}_2$ ($\psi \neq 90°$) will only cause a decrease in the sensitivity of the device. The required sensitivity of the automatic compensator is determined by the choice of the amplifier gain. It will be seen from above graphs that the stabilization time of the system's moving parts is increased only very little even with a considerable deviation from the conditions $\alpha_1 = 0$, $\alpha_2 = 0$, and $\psi = 90°$.

Oscillograms of the balancing process in automatic compensators with the details mentioned above show that the balancing is completed even in the most impossible case in several seconds.

Figure 6 shows an oscillogram of the balancing process at the instant the measured voltage U_i is connected. The process is competed in 3.5 seconds.

By means of the oscillograms thus obtained it is possible to follow the nature of the compensating voltage variations during balancing and to construct a hodograph of the compensating voltage $\dot{U}_k$ vector.

Figure 7 shows a hodograph of the voltage vector $\dot{U}_k$ for the case of a sharp change in amplitude and phase of the measured voltage U_i. It will be seen from Fig. 7 that the compensating vector passes from its initial position $U_{k1} = U_{i1}$ to the final position $U_{k2} = U_{i2}$ along a hodograph approaching a straight line which joins the ends of the vectors.

This paper clarifies problems which arise in designing units of ac automatic rectangular-coordinate compensators and can be utilized by organizations which develop such instruments.

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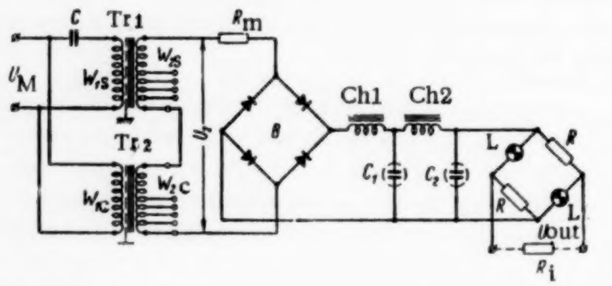
A STABILIZER FOR AN AUTOMATIC POTENTIOMETER MEASURING CIRCUIT SUPPLIES

V. V. Korotaev

When current stability of the order of 0.1-0.5% is required for the supplies of an automatic potentiometer measuring circuit, the use of the stabilizer developed by us can be recommended.

The figure shows the schematic of the stabilizer which is fed from 220 v mains and provides a voltage of 1 v across a load of 42 ohm.



The stabilizer consists of two stages connected to each other through a bridge rectifier with a smoothing filter. The components of the first stage are as follows: a 600 v μf capacitor (type KBG MP) and a saturated transformer Tr 1 wound on an enlarged Sh-16 core from a standard second-grade radio receiver transformer with a lamination pack 25 mm thick, comprise a ferroresonant circuit. Its primary winding (W_{1s} = 1800 turns) is wound with PÉL wire 0.25 mm in diameter. The secondary winding W_{2s} is wound with 284 turns of the same wire with five taps of two turns each. The windings are screened electrostatically from each other. The compensating unsaturated transformer TR2 is wound on core Sh-16 made of É41 brand steel with a 16 mm thick pack. Its primary winding (W_{1C} = 6600 turns) is wound with PÉL wire 0.01 mm in diameter. The secondary winding W_{2C} is wound with 95 turns of PÉL wire 0.25 mm in diameter with five taps of five turns each. There is an electrostatic screen between the two windings. The secondary windings of the two transformers are connected in opposing series.

The bridge rectifier B consists of 45 mm selenium discs. In order to decrease ripple, a filter is used which consists of choke Ch1 (core Sh-12 made of É41 brand steel with an 8 mm thick pack, wound with 500 turns of PEL wire 0.25 mm in diameter), choke Ch_2 (Sh-16 core of É41 steel with an airgap of 0.5 mm, a pack 20 mm thick, wound with 1600 turns of PÉL wire, 0.25 mm in diameter) and two 30 v electrolytic capacitors, C_1 and C_2 type KÉ-2-M of 100 μf each.

The second stage consists of a bridge circuit and is comprised of two nonlinear resistors L (incandescent lamps SM-30 with a nominal voltage of 28 v and current of 0.17 amp) and two manganin wire-wound resistors R of 145 ohm each. In order to reduce the effect of external vibration, the incandescent lamps are shock protected.

The wire-wound resistor R_m is used for matching the stabilization stages. On the basis of experimental data the nominal input voltage of the bridge stabilizer is taken as 14.9 v.

The stabilizer was tested over a long period. The arithmetic mean value of the stabilizer output voltage with simultaneous variations of the main voltage by ± 15%, frequency by ± 1% and ambient temperature from + 17 to + 30°C, was 0.9554 v. The maximum deviation from this mean (nominal) value was 0.2%.

With an ambient variation from + 15 to + 45° C, the stabilized voltage changed by 0.3%. During continuous working for 8 hours at an ambient temperature of + 45°C, the output voltage remained constant but differed from the nominal value by 0.14%.

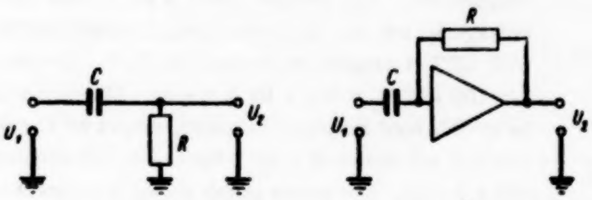
With slow variations of the mains voltage from 180-260 v and ambient temperature at + 20°C, the output voltage of the stabilizer did not vary and was equal to its nominal value.

ELECTRONIC CIRCUITS FOR DIFFERENTIATING DC VOLTAGES

A. S. Lifshits and Ya. I. Flid

For the solution of many problems it is necessary to obtain derivatives of functions of time, which in computer technique amounts to differentiating dc voltages. In many cases circuits used for this purpose should provide differentiations over a sufficiently wide range of frequencies (up to 10-30 cps).

The known differentiating circuits shown in Fig. 1 do not satisfy the required characteristics.

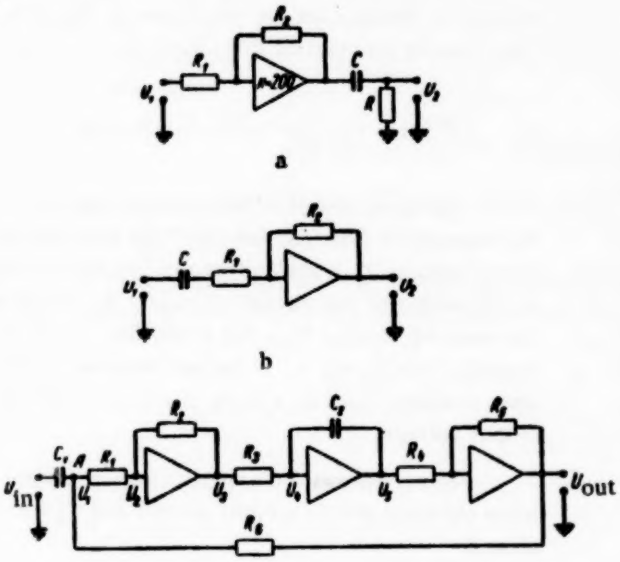


a b

Fig. 1

The circuit of Fig. 1,a provides differentiation of signals with frequencies ω < 1 cps. The circuit of Fig. 1,b cannot be used in practice owing to its instability.

In the present article several differentiating circuits, consisting of operational amplifiers are examined, their design is described and experimentally obtained characteristics of these circuits supplied. The tests were carried out by means of conventional amplifier UPT-4, which are linear in the range of measured output voltages of ± 100 v.



c

Fig. 2

<u>RC and dc amplifier differentiating circuits.</u> The frequency range of a differentiating RC network (Fig. 1,a) can be substantially increased if an amplifier is connected in series with it. Such a circuit is shown in Fig. 2,a. The amplification is provided by an operational dc amplifier. In order to avoid the amplifier zero drift affecting the operation of the circuit, the RC network is connected to the output of the amplifier. It is known that the transfer function of this circuit can be written as

$$W(p)=\frac{U_2(p)}{U_1(p)}=-\frac{kp\ T}{1+pT}, \tag{1}$$

where k = R_2/R_1 is the gain of the amplifier; T = = RC is the time constant of the differentiating circuit.

In a complex form the transfer function (1) has the form

$$W(j\omega)=-\frac{kj\omega T}{1+j\omega T}; \qquad p=j\omega. \tag{2}$$

For differentiation it is obviously necessary to have W(jω) = jω. Hence the amplifier gain must be k = 1/ T.

The error of differentiation is determined by the denominator of (2). The amplitude and phase distortion in differentiation are determined with respect to the time constant T and frequency ω by the following formulas:

$$\Delta L=\left|\frac{1}{1+j\omega T}\right|=\frac{1}{\sqrt{1+\omega^2T^2}}; \ \Delta\varphi=-\mathrm{arctg}\,\omega T. \tag{3}$$

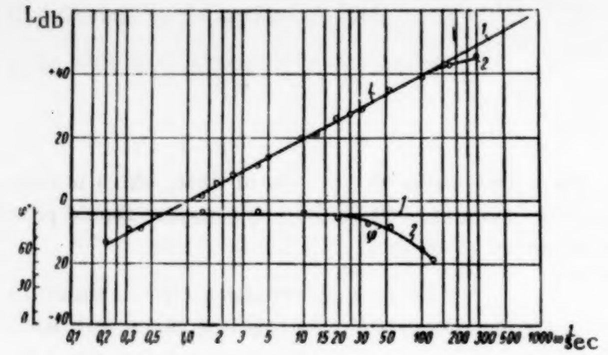


Fig. 3. Ideal differentiation; 2) experimental curve.

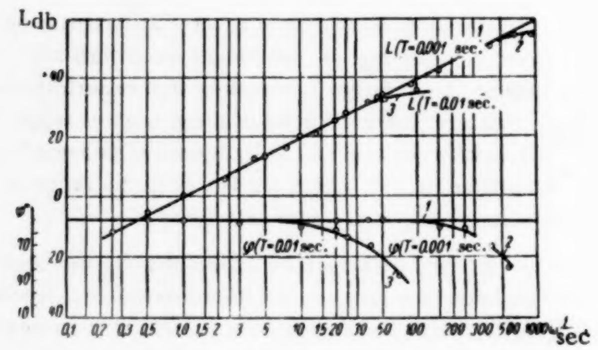


Fig. 4. Ideal differentiation; 2 and 3) experimental curves.

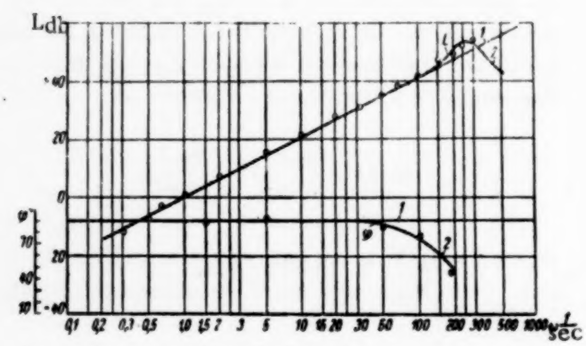


Fig. 5. Ideal differentiation; 2) experimental curves.

Setting the errors at ΔL and $\Delta\varphi$ and solving Eq. (3) with respect to ω we have

$$\omega=\sqrt{\frac{1-\Delta L^2}{T^2\Delta L^2}} \qquad \omega=\frac{\operatorname{tg}\Delta\varphi}{T}. \tag{4}$$

Setting the amplitude and phase errors and the time constant T at permissible values it is possible to find from (4) the top limit of differentiating frequencies. The bottom limit is set by the induced voltage which for the circuit under consideration with UPT-4 amplifiers is equal to $U_i = 0.2$ v for k = 100 and $U_i = 0.9$ v for k = 400. The experimentally obtained frequency characteristics of above circuits are shown in Fig. 3 for T = 0.005 seconds and k = 200. The same graph shows the curves of an ideal differentiator.

In order to obtain satisfactory results the circuits with the operation amplifier shown in Fig. 2,a should be changed for the one shown in Fig. 2,b. The transfer function of this circuit is

$$W(p)=\frac{p}{1+pT_1};\ CR_2=1;\ T_1=CR_1. \tag{5}$$

The accuracy of differentiation can obviously be determined from (3) and (4). The decrease of time constant T_1 is limited by the induced voltage at the output of the circuit. Thus, for $T_1 = 0.01$ sec the induced voltage $U_i = 0.2$ v and for $T_1 = 0.001$ seconds, it is $U_i = 1$ v. A further decrease of the time constant leads to a sharp rise in the induced output voltage.

Figure 4 shows the experimental characteristics obtained for $T_1 = 0.001$ second and $T_1 = 0.01$ second.

Differentiating circuit with integrating amplifiers. Since integration is the opposite to differentiation, it is possible to use integrating amplifiers in a differentiating circuit. In this case the circuit shown in Fig. 2,c was found to be the most suitable. It can be easily shown that the transfer function of this circuit is

$$W(p)=\frac{U_{out}(p)}{U_{in}(p)}=\frac{T_1p}{1+pA+p^2B},$$

where

$$T_1=C_1R_6;\quad k_1=\frac{R_2}{R_1};\ A=\frac{T_2}{k_1k_2}+\frac{T_2R_6}{k_1k_2R_1};$$
$$B=\frac{T_1T_2}{k_1k_2};\quad T_2=C_2R_3;\quad k_2=\frac{R_5}{R_4}. \tag{6}$$

In a certain frequency range with appropriately selected parameters when the product of k_1k_2 is sufficiently high, terms pA and p^2B can be neglected as compared with 1. Then with $T_1 = 1$, expression (6) provides an ideal differentiating link.

The accuracy of differentiation depends on the value of the denominator of expression (6). If the transfer function is written in a complex form, it becomes possible to determine the errors of differentiation by the modulus and angle:

$$\Delta L = \frac{1}{\sqrt{(1-\omega^2 B)^2+\omega^2 A^2}}, \tag{7}$$

$$\Delta\varphi = -\operatorname{arctg}\frac{\omega A}{1-\omega^2 B}. \tag{8}$$

The upper limit of the differentiating frequencies can be determined by the permissible values of ΔL and $\Delta\varphi$ from (7) and (8), solved with respect to ω.

Above circuit was checked experimentally for $k_1 = k_2 = 100$, $T_1 = 1$ second, $T_2 = 0.25$ second, $R_1 = R_4 = 10$ kilohm, $C_1 = 1$ μf and $C_2 = 0.25$ μf.

The circuit includes three amplifiers in order to obtain a greater gain and thus decrease the errors of differentiation. A further increase in gain leads to instability owing to phase shifts in amplifiers. The experimentally obtained frequency characteristics of the circuit are given in Fig. 5. The large feedback in the circuit decreases the induced voltage to $U_i = 0.1$ v, which provides the differentiation of low-amplitude input signals in the region of frequencies.

CONCLUSIONS

Above differentiating circuits provide for voltage differentiation in the frequency range of 10-30 cps, according to the circuit used.

The differentiating circuit with integrating amplifiers has smaller induced voltages and therefore provides differentiation of small-amplitude input signals over a wide frequency range.

AUTOMATIC SORTER OF PERMANENT MAGNETS

É. Z. Akhtyamov

The author has developed, produced and brought into use, an automatic sorter of cylindrical permanent magnets [1]. The schematic of the measuring mechanism of the sorter is shown in Fig. 1.

The magnets were checked by determining the open-circuit magnetic flux with a fluxmeter measuring coil by means of a method involving the release of the coil from the neutral plane of a magnet previously magnetized to saturation.

It is known that testing magnets involves considerable difficulties owing to the labor-consuming and lengthy process involved and the requirement of magnetizing in advance the magnets under test.

The principle of measuring the residual magnetic induction in a small airgap of the magnetic circuit, which led to the automation of the process, consists of the following.

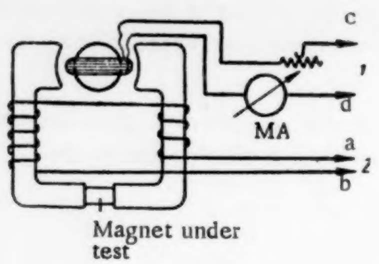


Fig. 1.

It is known that the torque in moving-coil instruments with a radial field is represented by the formula

$$T_q = \frac{2rlnBI}{9810} \text{ gauss-cm} \qquad (1)$$

where 2r is the radial width of the coil, cm; l is the effective height of the coil, cm; n is the number of turns in coil; B is the magnetic induction in the airgap of the magnetic circuit; gauss; I is the current, amp.

Providing 2r, l, n and I are constant, Tq will be a function of B.

Hence,(1) will take the form

$$B = \frac{T_q \cdot 9810}{2rlnI} \text{ gauss} \qquad (2)$$

Thus, it will be seen from (2) that if the current I in the coil is constant, the Tq of a moving-coil instrument will be proportional to changes in the airgap magnetic induction B.

The remaining functions of the automatic sorter are: ensuring the feeding of magnets into the magnetic circuit of the moving-coil instrument, ensuring their magnetization, further sorting, and further count of good and faulty magnets.

The kinematic diagram of the sorter is shown in Fig. 2.

A contact disc 2, eccentric cam 3, and a maltese cross are firmly fixed to spindle 1. For each turn of the spindle the maltese cross rotates, turning disc 5 through 90°.

At the instant the magnets under test are placed in the magnetic-circuit airgap of the measuring mechanism 6, shoulder 7 closes contacts 8 and sends current pulse to the magnetizing windings 9 from a thyratron magnetizing device, whose schematic is shown in Fig. 3. The magnet being tested is magnetized to saturation, and if a stabilized current is applied to coil 10, it will deflect to an angle proportional to the induction in the gap between the core and the magnetic circuit.

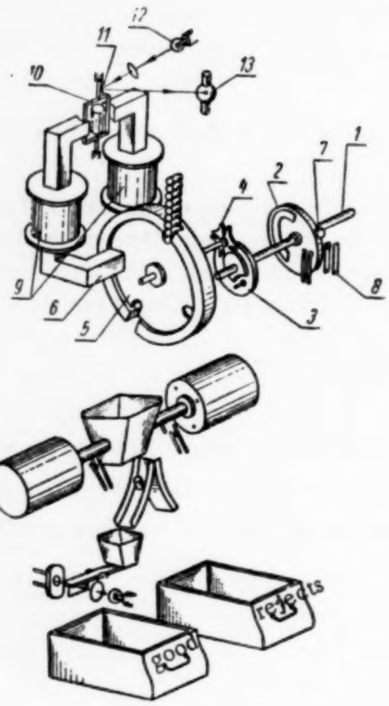


Fig. 2.

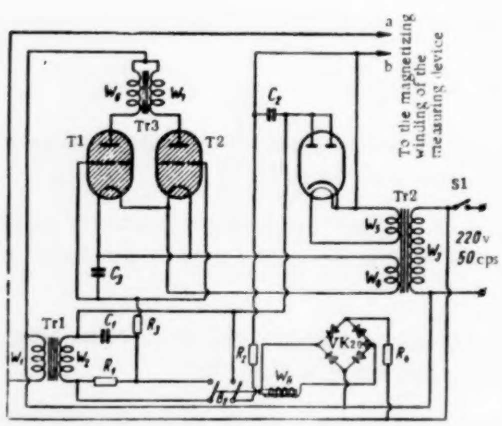


Fig. 3

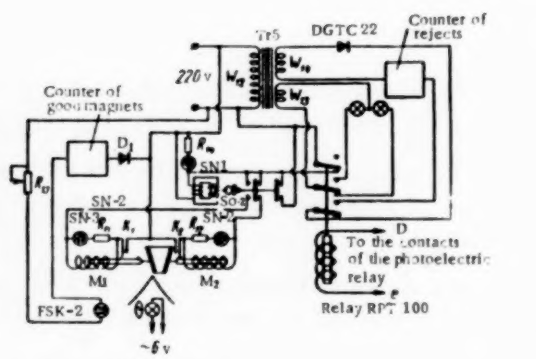


Fig. 4

In order to prevent the instantaneous magnetic field affecting the coil, it is shunted.

The stabilized supply for the coil is taken from the circuit of the tube voltmeter VSK-7B.

When the coil is rotated through a certain angle, the light from lamp 12 is reflected from the spherical mirror 11, fixed to the coil and falls on the photoelectric cell 13. In order to prevent false operation of the photoelectric relay, lamp 12 is switched on only when coil 10 has reached a stable state. If the light falls at an angle smaller than the one set by calibration, the photoelectric relay connects the sorting electromagnet, which displaces hopper 14 and directs the magnet under test to the tray marked "Reject".

Simultaneously with the sorting electromagnet, a counter of rejects is switched in and the circuit controlling the sorting electromagnets, shown in Fig. 4, operates.

If the light from the lamp 12 is deflected by an angle larger than the one set by calibration, the light does not shine on the photocell (the photoelectric relay does not operate) and only the systems of the dropping mechanism, magnetization and the counting of good magnets operate.

The calibration of the automatic sorter was carried out with magnets which had been checked by VNIIM and had the required certificates.

The automatic sorter successfully passed its tests.

The output of this automatic sorter model amounted to 600 magnets per hour. This figure can be improved in the future.

At present, work is proceeding for replacing the existing loading frames by a hopper.

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DECATRON COMPUTER WITH A PRESET TIME OR PULSE COUNT

I. Ya. Breido

The use of gas-discharge decimal counting tubes, known as decatrons, proves economical in thermionic, semiconductor, and other elements in computer design [1, 2]. That fact plus their compactness and economy in use, make decatrons successful replacements for tube circuits as well as mechanical registers [3, 4]. Decatrons are extensively employed in various devices of commercial and scientific value, such as telemetering devices, computers for experimental nuclear physics, memory units of digital computers, electrical measuring instruments with digital displays, electronic tachometers, frequency dividers, precision timers (producing time pips), etc.

Below, a brief description of a computer is given which operates with Soviet-made mass-produced decatrons and contains a unit for presetting the required counting time or pulse count. The block schematic of the instrument is given in Fig. 1. It performs the following operations: 1) counting of pulses over an arbitrary time with manual starting and stopping; 2) counting pulses with automatic stopping after a given time (time presetting); 3) automatic measurement of the duration of counting of a set number of pulses (pulse-count presetting).

The counted pulses are fed from the input through lock 1 to unit decade 2, and from there to the following decades of the counting channel. From the output of the stages of hundreds, thousands, etc., the signals can be transmitted through precomputer switch 15 and shaping stage 14 to trigger 13 which controls locks 1 and 18.

Standard 100 cps pulses are produced by converter 16 and fed to decatron 17, which reduces the frequency to 10 cps (period of 0.1 second). From the stage the pulses are fed through lock 18 to the 0.1 second stage and following stages – 20, 21, etc. From any of these stages the pulses can be fed through precomputer switch 15 to the shaping stage 14 and trigger 13.

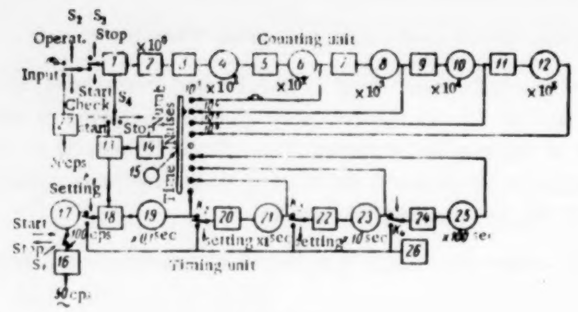

Fig. 1

When operating with a preset count, switch 15 is placed in the required position of the "numb. pulses" section, the counting and timing units are restored to zero, and then the computer is started by means of switch S_1. After the preset number of pulses (10^3, 10^4, 10^5 or 10^6) is recorded, trigger 13 receives a pulse from the appropriate stage and closes locks 1 and 18. The counting time is read-off decatrons 19, 21, 23, and 25.

When operating with a preset time, switch 15 is placed in the required position of the "time" section, both units are restored, and the computer is started. After the lapse of the preset time (1, 10, 100 or 1000 seconds) trigger 13 receives from the corresponding stage (21, 23, or 25) a tripping signal which closes the locks. The number of pulses is read off the signal lamps and decatrons of the counting unit. If the required time, however, does not amount to 10, 100 or 1000 seconds, but, to say 60 seconds, decatron 23 ("x 10 seconds") is adjusted, after resetting to zero, by means of "setting" button B_3 to 100−60 =40 seconds, i.e., its discharge glow is set to the pin 4 so as to make the tripping pulse operate trigger 13 in 60 seconds from the time of starting. Push buttons B_1−B_2 serve to connect the inputs of stages 20, 23, and 24 to the 1 cps pulse generator 26, thus providing the possibility of "setting" in turn the required numbers on decatrons 21, 23 and 25 (by means of visual observation).

The first stage of the counting unit consists of electronic tubes, the second and following decades of decatrons. The instrument can be made with different resolution times τ_r to meet various requirements. An instrument with $\tau_r \approx 20$ μsec is described in [5]. Smaller values of τ_r are obtained by using fast operating electronic tubes in the first decade [6-8] and fast operating decatrons type OG3 [9, 10] in the second. If the computer is to work with gas-discharge counters ($\tau_r \geq 50$ μsec) decatron OG3 can be used in the first decade.

The main elements of the instrument's operational circuit are shown in Fig. 2. The upper portion (Fig. 2,a) contains the counting unit stages, starting with "hundreds", the lower portion (Fig. 2,b) the unit for setting the time and the number of pulses. The stages shown in the drawing use OG-1 decatrons, since the speed of counting of these stages in the majority of computers does not exceed 10^3 pps.

The counting unit contains 6 decades (the input 1st and 2nd stages are not shown in Fig. 2.); the counting capacity amounts to 10^6-1; at the 10^6th pulse the circuit returns to its initial condition. From the decades of hundreds, thousands and so on, connections are taken out to the setting switch P_1 (Fig. 2,b). When this switch is set to the "number of pulses" section in positions "10^3", "10^4", etc., at the instant the recording of the set number of pulses is completed, trigger T_{11} receives (Fig. 2,b) a tripping pulse, the left hand side tiode of T_{11} is unblocked and locks both units. As the result, the counting of time and signal pulses stops.

The time presetting unit has a capacity of 1000 seconds. It consists of 5-decatron OG5 stages (Fig. 2,b). The time signals are obtained from the commercial supply frequencies (50 cps) which in the majority of industrial centers is maintained with an accuracy sufficient for the greater part of operations performed with this type of instrument. If required, it is possible to feed to terminals "120" instead of the commercial supply voltage another voltage, for instance, from a 500 cps tuning-fork generator (having amplified its output to 120 v across 10 kilohm). The time scale will, of course, change accordingly.

The ac voltage is rectified by the germanium diodes and a negative pulse of double the original frequency is fed to the guides of decatron T_1. In the output cathode circuit of decatron T_1 positive pulses follow each other at intervals 10 times greater than at the input, i.e. at 0.1 second, when fed from the commercial supply mains. The pulses arrive at lock T_2 which is controlled by trigger T_{11} and also serves as the shaping stage for the tenths of a second decatron T_3. From this decatron the pulses are fed to the shaping amplifier T_4 of decatron T_5, etc.

The initial setting of the required time is carried out by means of the presetting switch S_1 (in the "time" section position) through which a positive pulse is fed from the output cathode of the corresponding decatron to the shaping stage T_{12}. The shaped negative pulse is fed from the anode circuit of T_{12} to the grid of the normally conducting right-hand-side triode of trigger T_{11} which it trips, thus locking the counting and timing units.

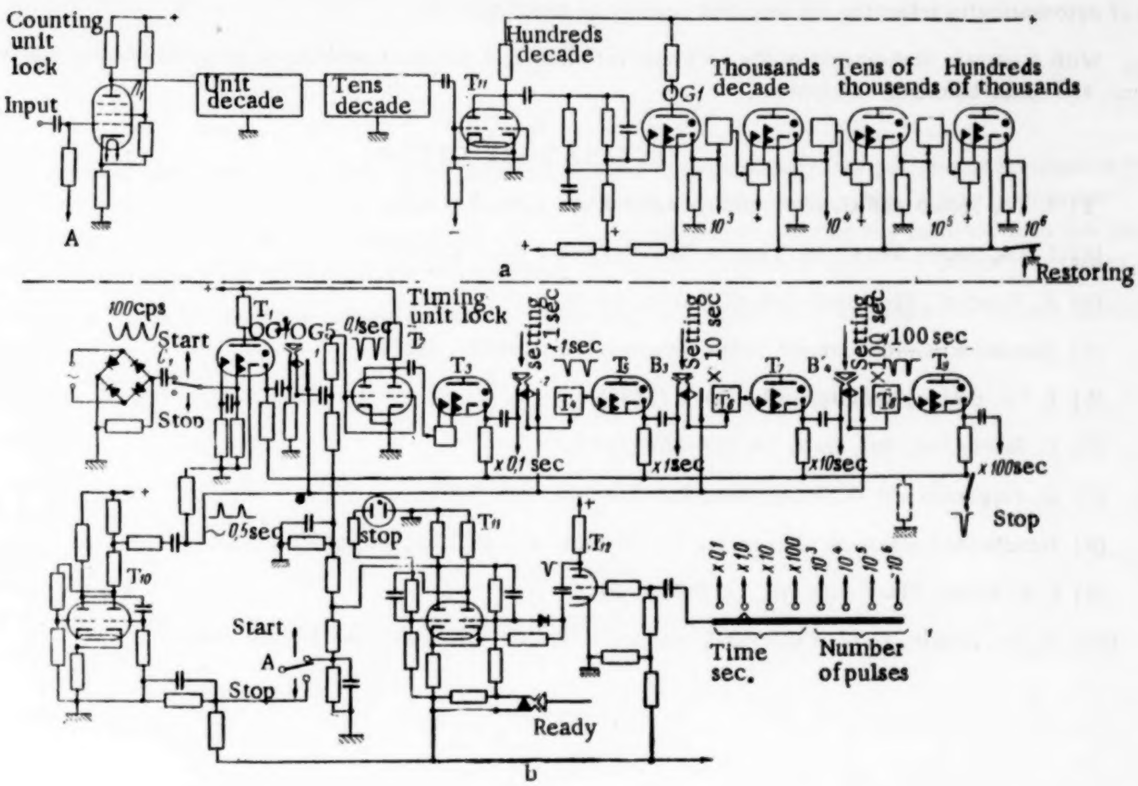

Fig. 2

The grid circuit of each of the shaping stages T_2, T_4, T_6, and T_8 can be switched by means of push buttons B_1-B_4 to the line of the setting pulse generator T_{10}* (in the "setting" position Fig. 1). The pulses of this generator are transmitted at the rate of 1 cps and are used for additional presetting of decatrons T_3, T_5, T_7 and T_9, when counting time is not a multiple of 10 seconds (for instance if the counting is carried out during t = 1 minute = = 60 seconds, the tens of seconds decatron T_7 must be placed in position 4 – see above).

When working with a set number of pulses, a small systematic error is inevitable, which is due to the retardation of the pulse at the output of each decatron as compared with the last starting pulse received at the input. This lagging is equal to the time taken by the changeover of the discharge from the 9th guide to the output cathode and amounts to 200-400 μsec per decatron. The lagging of the final pulse at the output of the last decatron of the group which has been connected is recorded in the counting unit since the preceding stages of the group will continue to operate unitl the unit is locked. For instance, with a set number of 100,000 pulses the total lag of the decatrons connected in the circuit can amount to 2 msec, so that at a count rate of 50,000 pps about 100 "extra" pulses will be recorded which amounts to a calculable error of ± 0.2%. With a smaller rate of count the number of "extra" pulses becomes proportionately smaller.

The error can be decreased by altering the system of interstage transfers: the starting of a succeeding stage should be carried out by the trailing edge of the pulse at the 9th pin of the decatron instead of the leading edge of the pulse at the output cathods. The simplest way of achieving this schematically is by having a lead-out at the ninth pin of the guide. For this purpose the double pulse decatrons (types OG1, OG2, and OG5) should have their zero count transferred from the index cathode to the first pin by sending to the input of all the decatrons after resetting a general zero setting pulse (gating pulse). The output cathode, which has a separate lead-out, will thus receive the ninth pulse, whose trailing edge will lag very little behind the last (i.e. tenth) input pulse.

CONCLUSION

The automation of the setting of the count to a given time or number of pulses offers great advantages in the use of digital computers in experimental nuclear physics; in particular the operator becomes able to attend

* Instead of the generator a telephone dial can be used.

to several pieces of equipment at this time. In industry, a computer with a preset pulse count offers the possibility of automatically selecting the required number of articles.

With a certain elaboration of the lock control circuit, it becomes possible to program control machine tools, ovens, and other industrial equipment.

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UNIVERSAL DC DEVIATION BRIDGES

B. A. Seliber, S. G. Rabinovich, and M. B. Mints

Deviation bridges exceed conventional dc bridges in their speed of operation and in many instances in their accuracy. Their wide application, however, is hindered by the difficulties of making deviation bridges which could measure resistances over a wide range.

If an electrical measuring instrument (galvanometer) is used in the bridge as an indicating instrument, the relation between the current I_g flowing through it and values of the bridge-arm resistances (Fig. 1) is expressed by the equation [1]:

$$I_g = U_0 \frac{r_x r_3 - r_2 r_4}{r_g(r_x + r_2)\cdot(r_3 + r_4) + r_3 r_4(r_x + r_2) + r_1 r_2(r_3 + r_4)} \quad (1) \qquad (1)$$

In order to determine the possibility of using this bridge for measuring deviations, it is convenient to express Eq. (1) in slightly different form. Let us denote

$$r_x = r_1(1+\gamma),$$

where r_1 is the nominal value of the resistance under test; γ is the relative error of the measured resistance.

Resistance r_1 is related to the resistances of the remaining arms of the bridge by the ratios

$$\frac{r_1}{r_2} = \frac{r_4}{r_3} = n. \qquad (2)$$

In conjunction with the adopted notations Eq. (1) will take the form

$$I_g=\frac{U_0 n}{n+1}\cdot\frac{\gamma}{r_1(1+\gamma)+r_4\left(1+\frac{1}{n}+\gamma\right)+nr_g\left(1+\frac{1}{n}+\gamma\right)}. \tag{3}$$

Expression (3) shows that in the case under consideration the current through the galvanometer depends not only on the relative error of the measured resistance, but also on its absolute value. The latter circumstance reduces the range of measurement in bridges of this type. The introduction of correcting resistances in the galvanometer or supply circuits [2] and other similar measures do not eliminate to a sufficient extent this defect.

It is better to use in deviation bridges indicators with a high input resistance and measure voltage instead of current.

From (3) we can easily obtain

$$U_g=\frac{U_0}{n+1}\cdot\frac{\gamma}{\frac{r_1(1+\gamma)}{r_g n}+\frac{r_4\left(1+\frac{1}{n}+\gamma\right)}{r_g(n+1)}+1+\frac{1}{n}+\gamma}. \tag{4}$$

If we assume that $r_1 \ll r_g$ and $r_4 \ll r_g$ the latter expression becomes

$$U_g=\frac{U_0}{1+n}\cdot\frac{\gamma}{1+\frac{1}{n}+\gamma}. \tag{5}$$

From (4) and (5) we can see that the possible measuring range of a given bridge is determined by the inequality $r_1 \ll r_g$ (the value of r_4 can be chosen arbitrarily by the designer).

In order to evaluate the error due to the finite value of r_g, let us transform (4):

$$\begin{aligned} U_g&=\frac{U_0}{n+1}\cdot\frac{\gamma}{1+\frac{1}{n}+\gamma}\cdot\frac{1}{1+\frac{r_1}{r_g}\cdot\frac{1+\gamma}{n\left(1+\frac{1}{n}+\gamma\right)}+\frac{r_4}{r_g(n+1)}}\simeq \\ &\simeq\frac{U_0}{n+1}\cdot\frac{\gamma}{1+\frac{1}{n}+\gamma}\cdot\left[1-\frac{r_1}{r_g}\cdot\frac{1+\gamma}{n\left(1+\frac{1}{n}+\gamma\right)}-\frac{r_4}{r_g(n+1)}\right]. \end{aligned} \tag{6}$$

By comparing (5) and (6) we find the relative error φ_r of the deviation bridge due to the finite value of the measuring diagonal resistance:

$$\varphi_r=-\left[\frac{r_1}{r_g}\cdot\frac{1+\gamma}{n\left(1+\frac{1}{n}+\gamma\right)}+\frac{r_4}{r_g(n+1)}\right]$$

or assuming $\gamma \ll 1$ we obtain

$$\varphi_r=-\frac{r_1+r_4}{r_g(n+1)}. \tag{7}$$

In some cases it is necessary to have a bridge with several measuring ranges, i.e., a bridge whose full-scale pointer deflections correspond to different values of the measured resistance deviations. It will be seen from (5) that in such a bridge an additional error will arise at different measuring ranges. If it is assumed that the scale of the output instrument is calibrated at $\gamma \ll 1$, at larger deviations an error φ_γ will arise, which can be calculated

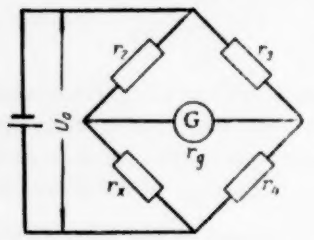

Fig. 1

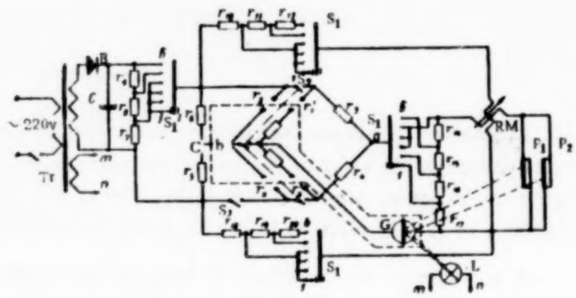

Fig. 2

from the formula below, easily obtainable from (5):

$$\varphi_\gamma = \frac{n\gamma}{n+1}. \tag{8}$$

In addition to the above errors peculiar to the deviation bridges, there can also arise errors characteristic of bridges in general.

Dc tube amplifiers can be used as indicators with a very high input resistance. Their insufficiently high gain, however, necessitates the use of relatively high supply voltages and dissipation of considerable power in the bridge arms and the measured resistance.

A much greater sensitivity can be obtained if the voltage at the output is measured by means of a dc potentiometer. Such potentiometers can be either manually operated or automatic. In all the cases the potentiometer input resistance is determined by the measured voltage and the unbalanced current. Owing to the great sensitivity of zero indicators used in potentiometers, this resistance can be very high indeed. Amplifiers with a large negative feedback, in particular photocompensator galvanometer amplifiers [3, 4] can be used as automatic potentiometers.

Above relations hold for bridges working with a given voltage supply. Since in this case the arms ratio of the bridge must be constant ($n = r_4 / r_3 = \text{const}$) r_2 should be considered as the comparison arm (Fig. 1).

By analyzing in a similar manner the operation of bridges with a constant current, it is possible to arrive at the conclusion that for deviation bridges in this case it is advisable to use an indicator with the lowest possible resistance and measure the current instead of voltage at the bridge output.

If we assume that $r_g \ll (r_1 + r_4)$ and $r_g \ll (r_2 + r_3)$ and denote $r_1/r_4 = r_2/r_3 = m$ (the resistances correspond to the circuit in Fig. 1), it is easy to obtain that

$$I_g = \frac{I_0}{1+m} \cdot \frac{\gamma}{1+\frac{1}{m}+\gamma}. \tag{9}$$

Now resistance r_4 serves as the comparison arm. The resistors r_2 and r_3 serve as the ratio arms.

It follows from (5) and (9) that the voltage or current at the bridge output have a single value relative to the measured error γ only if condition $U_0 = \text{const}$ or $I_0 = \text{const}$ hold, respectively. It is often difficult to ensure a constant supply to the bridges. It is usually best to use as an output instrument a ratio meter, which eliminates the effect of supply voltage or current changes on the measurement results.

On the basis of above consideration, deviation bridge R19 was developed and made at the "Vibrator" plant. The bridge has a range of 1 ohm to 1 meg, and has three ranges of deviation measurements: ± 0.25, ± 2.5, and ± 25%. The graduations of these ranges are respectively 0.01, 0.1, and 1%. The comparison arm is not included in the bridge. In normal industrial measurements when an accuracy of 0.1-0.3% is satisfactory, a conventional

Fig. 3

resistance box, for instance of the KMS-6 type, can serve as a comparison arm. In order to obtain a greater accuracy precision boxes or specially made standard resistors should be used. The ratio of the bridge arms was taken as n = 1. The resistance of the comparison arms must, therefore, be equal to the nominal value of the measured resistance.

A simplified circuit of the bridge is given in Fig. 2. The resistance under test is connected to terminals r_x, and the standard resistor to terminals r_n. The ratio arms incorporated in the bridge are $r_3 = r_4 = 1000$ ohm. The bridge works from ac mains through transformer Tr, using rectifier B and a smoothing capacitor C. The voltage at the output of the bridge is measured by means of a photocompensation amplifier, which consists of a galvanometer G on torsion suspensions, an illuminating lamp L with a simple optical system, two photocells P_1 and P_2 connected differentially and compensation resistors r_{14} and r_{17}. The output of the amplifier is connected to a ratiometer RM.

When there is no voltage at the output of the bridge the photocells are equally lighted and there is no current flowing in the compensating resistors. The ratiometer is in its zero position. If at the amplifier input, however, there appears a voltage, it will deflect the galvanometer and redistribute the light on the photocells, producing in them differential photoelectric current, and across the compensation resistors a voltage, which will tend to balance out the voltage at the input of the amplifier. Providing the compensation resistor remains constant, the value of the photoelectric current read on the ratiometer can serve as a measure of the disturbing voltage, i.e., of the percentage deviation under consideration. The bridge amplifier does not differ in its construction from the photocompensation amplifier of the semiautomatic potentiometer R2 [5].

In order to make the ratiometer scale suitable for the entire resistance range, it is necessary to have a sufficiently high amplifier input resistance. The full-scale deflection of the ratiometer used in the photocompensation amplifier is 15–0–15 μa. A current of the order of $(1-3)\cdot 10^{-9}$ amp in the input circuit of the amplifier will produce the 15 μa at the output. This can be attained with an amplifier input resistance greater than 300 meg / v, which can be maintained sufficiently large by an appropriate choice of the bridge supply voltage. Taking also into consideration the power dissipated in the bridge resistances and striving to reduce this power, the resistance range of the bridge was divided into two sections: 1 ohm to 1 kilohm and 1 kilohm to 1 meg. In the first range the supply voltage of the bridge remains the same for all the three deviation scales at 0.5 v and the maximum power dissipated in the measured resistance does not exceed 0.1 w. In the second resistance range the maximum voltage is used with the ± 0.25% scale and amounting to 20 v. The power dissipated in the measured resistance, however, does not exceed 0.1 w.

The choice of the range and scale of measurement is made with a six-position, four-pole switch $S_1^{I}-S_1^{IV}$. Poles S_1^{I} switches the bridge supplies, S_1^{II} and S_1^{IV} change the multiplying resistances $r_{10}-r_{12}$ and $r_{18}-r_{20}$ in the ratiometer reaction coil circuit, S_1^{III} switches the photoamplifier compensation resistors. Switch positions 1-3 correspond to 1 ohm – 1 kilohm range. In position 1, deviation scale $\gamma = \pm 0.25\%$ is used. Positions 2 and 3 correspond to scales ±2.5 and ±25%, respectively.

Positions 4-6 provide the 1 kilohm – 1 meg range, with scales ± 25, ± 2.5 and ± 0.25%, corresponding to positions 4, 5, and 6.

The ratiometer is calibrated on the 0.25% scale with small values of the measured resistance. When measuring less precise resistors in the ranges of ± 2.5 and ± 25% or resistors of higher values, additional corrections φ_γ and φ_r must be applied according to Eqs. (7) and (8). These additional corrections can, however, be neglected in practice. Thus, for instance, when measuring resistors of the order of 1 meg, which deviate from their nominal value by 0.25%, the input resistance of the amplifier is at least 5 meg and $\gamma_r \leq 10\%$, i.e., the instrument will measure 0.23 or 0.27% instead of 0.25%. Moreover, the less the measured resistance differ from its nominal value (i.e., the smaller the γ) the more precise do the bridge readings become. It is easy to see that error φ_γ does not essentially affect the readings either. For instance, in the worse case when $\gamma = 25\%$, $\varphi_\gamma = 12.5\%$, i.e., the instrument will read 22 or 28% instead of 25%. Thus, in both instances we are dealing with quantities of the second order of magnitude compared with the measured deviations.

In measuring resistances smaller than 100 ohm, when it is advisable to avoid the effect of contact resistances and connecting leads, a double bridge circuit can be used. For this purpose the live ends of measured and standard resistances are connected to terminals r'_x and r'_2 and switch S_2 is placed in the position shown in Fig. 2.

The bridge could not be made highly accurate without eliminating the effect of leakages. With this object in view the screening shown by adotted line in Fig. 2 was used in the bridge. The screened components are separated from the rest and the case of the instrument by two insulated layers, between which a metal screen is placed and connected to point c of the circuit. The potential of point c is adjusted by means of potential dividers r_5 and r_6 to that of point a. Since the bridge is not completely balanced, point b has a small voltage U_g withrespect to the screen. This voltage, however, does not exceed 30 mv and the effect of the leakage caused by it is negligible.

The measuring mechanism of the ratiometer is a most vulnerable place from the leakage point of view. This is due to one of the ratiometer coils being connected to the measuring diagonal and the other to the supply of the bridge. It is constructionally too difficult to place a screen between the two coils. Therefore the potential of the coil connected to the supply is made equal to that of the measuring diagonal of the bridge. For that purpose the multiplying resistors of the reaction coil are divided in half and connected symmetrically on either side of the coil (resistors r_{10}-r_{12} and r_{18}-r_{20}).

Figure 3 shows the appearance of the bridge. The ratiometer scale is 130 mm long and has 25 divisions on either side of the zero. The ratiometer decay time from the instant the amplifier is connected does not exceed 4 seconds. The power consumption of the bridge amounts to 50 w. Its external dimensions are 410 × 300 × × 180 mm. Its weight is 12 kg.

It follows from the above that the application of a photocompensation amplifier provided the possibility of developing a direct-reading deviation bridge which provides the comparison of resistances with their nominal values in the range of 1 ohm to 1 meg, both with large deviations up to ± 25% for the commercial-type resistors and small deviations not exceeding 0.01% for the precision type.

The combination of the enumerated properties makes the deviation bridge type R19 a universal instrument whose use in plants making electrical resistors of medium and high precision is desirable.

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MEASUREMENTS OF SAW-TOOTH VOLTAGE DISTORTIONS

B. A. Zemel'man

Among discrete-action electronic measuring instruments, often called digital display electronic instruments, there is a large group of instruments whose operation is based on comparison of the measured quantity with a standard saw-tooth voltage. The error of measurement of these instruments depends to a great extent on the linearity of the saw-tooth voltage. This parameter of the instrument, the deviation from linearity of the standard voltage, can be determined by checking the instrument against a standard one. In designing such instrument, however, it is required to determined the linearity of the generator voltage before the instrument is made in order to be able to select a suitable generator circuit. In this connection various methods of measuring the linearity of saw-tooth voltages are being developed.

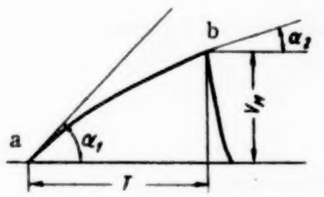

Fig. 1

One of most convenient methods of determining the linearity of the voltage is based on differentiating the saw-tooth voltage and then measuring the differentiated portion which corresponds to the effective part of the saw-tooth voltage [1]. This measurement is difficult because the selected portion of the differentiated pulse constitutes a very small part of the differentiated pulse as a whole when the deviation from linearity is small.

The All-Union Scientific Research Institute of the Committe of Standards, Measures and Measuring Instruments developed a device which provides the possibility of measuring small deviations from linearity of a saw-tooth voltage with the required accuracy.

The deviation s from linearity of a saw-tooth voltage is usually determined by the following expression (Fig. 1):

$$s = \frac{\operatorname{tg}\alpha_1 - \operatorname{tg}\alpha_2}{\frac{U_M}{T}}. \qquad (1$$

As the result of differentiation a pulse shown by dotted line in Fig. 2 should be obtained. Since, however, actual differentiating elements cannot provide ideal differentiation, the pulse thus obtained corresponds (the full line in Fig. 2) to the derivative of the effective portion (a-b) of the saw-tooth voltage only starting from a certain point c. The time interval t_1 during which the pulse in Fig. 2 does not correspond to the derivative depends on the parameters of the differentiation circuit. It is obvious that with a known U_M and T the deviation s from linearity can be determined by measuring voltage ΔU_d.

In order to find out to what extent the parameters of the differentiating circuit affect the determination of linearity, it is necessary to express the saw-tooth voltage in an analytical form.

Let us assume that the effective portion of the saw-tooth voltage is expressed in the following manner:

$$u_1 = \frac{U_M}{T(1-aT)}(1-at)\,t. \qquad (2)$$

Coefficient a determines the deviation from linearity of voltage u_1.

$$\frac{du_1}{dt} = \frac{U_M}{T(1-aT)}(1-2at). \qquad (3)$$

Hence,

$$s = \frac{2aT}{1-aT}. \qquad (4)$$

Since we are interested in determining a small deviation, we can assume the product aT to be small and negligible compared with unity. Then it is possible to write

$$u_1 = \frac{U_M}{T}(1-at)\,t, \tag{5}$$

$$\frac{du_1}{dt} = \frac{U_M}{T}(1-2at), \tag{6}$$

$$s = 2aT. \tag{7}$$

As a result of differentiation of voltage u_1 by means of an RC circuit we obtain voltage *

$$u_d = \frac{U_M}{T}(1-2at)\left[1 + \frac{2a\tau-(1+2a\tau)\,e^{-\frac{t}{\tau}}}{1-2at}\right]. \tag{8}$$

The second term in the square brackets represents the relative error of differentiation δ:

$$\delta = \frac{s\frac{\tau}{T}\left(1+s\frac{\tau}{T}\right)e^{-\frac{t}{\tau}}}{1-s\frac{t}{T}}. \tag{9}$$

In order to make δ sufficiently small it is necessary to make time constant τ small as compared with the pulse duration T. Taking into consideration that in the cases of interest to us $s \ll 1$, expression (9) can be written in the following manner:

$$\delta \simeq s\frac{\tau}{T} - e^{-\frac{t}{\tau}}. \tag{10}$$

Taking as the maximum permissible time interval $t_1 = aT$ with which the error of differentiation will not exceed the permissible value δ_{pr} we can write

$$\delta_{pr} = s\frac{\tau}{T} - e^{-a\frac{T}{\tau}}. \tag{11}$$

From (11) it is possible to find the maximum permissible value of ration (τ/T) for which $\delta \le \delta_{pr}$. The set coefficient α determines the initial portion of the voltage u_1 curve whose deviation from linearity cannot be determined with the value of (τ/T) corresponding to (11). With decreasing τ this initial portion also decreases and the measurement of linearity can be made over a larger portion of the voltage u_1 curve.

If error δ is neglected the difference of the differentiated pulse amplitudes which correspond to instants $t = 0$ and $t = T$ is equal to [see (8)]

$$\Delta U_d = U_M\, 2a\tau. \tag{12}$$

By comparing (12) with (7) we obtain

$$\Delta U_d = U_M \frac{\tau}{T} s. \tag{13}$$

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* Expression (8) was obtained with the assumption that by the beginning of each saw-tooth pulse the differentiating circuit capacitor had time to discharge. This assumption always holds in practice.

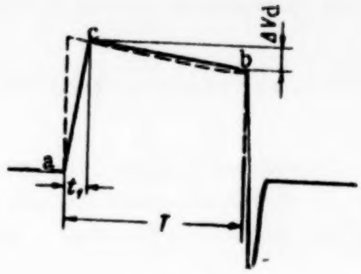

Fig. 2

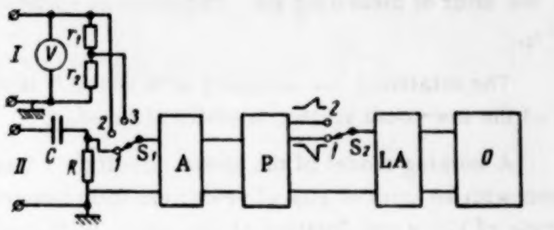

Fig. 3. I) Input of the calibrating voltage; II) input of the measured voltage.

Having measured ΔU_d it becomes possible to determine $\underline{s}$ from formula:

$$s = \frac{\Delta U_d}{U_M} \cdot \frac{T}{\tau}. \qquad (14)$$

As it was pointed out, in order to decrease the error of differentiation, it is desirable to make ratio (τ / T) as small as possible. This, however, decreases the voltage difference ΔU_d and makes it more difficult to measure.

Above relations have been obtained with the approximation of the saw-tooth voltage assumed in (2). It is obvious, however, that (13) and (14) will also hold in a general case.* . Error formula (10) can be different for another form of approximation, but in any case for a decreased error the ratio τ / T must be decreased.

The block schematic of the device developed by us is shown in Fig. 3.

In position 1 of switch S_1 the differentiated pulse is fed to amplifier A (one stage of half the tube 6N6P), next it passes to the phase inverter P (tube 6P9) limiter-amplifier LA (tube 6Kh6 and the second half of tube 6N6P) and finally oscilloscope O. The limiter-amplifier selects the top portion of the differentiated pulse and amplifies it. It is more convenient to limit pulses with one definite polarity. Since the device should be able to measure saw-tooth voltages of any polarity, a phase inverter is included in the circuit and provides the input of the limiter with single polarity pulses. The limiter is provided with the means of changing the level of limitation in order to be able to investigate voltages of different shapes and amplitudes.

The level of limitation and the gain of the oscilloscope are adjusted in operation in such a manner that the upper portion of the pulse is seen over the largest possible area of the screen. The length of segment Δh which corresponds to the measured voltage difference ΔU_d is recorded. Next the entire measured channel is calibrated.

For this purpose the equipment is provided with a potential divider $r_1 - r_2$ which is fed with a pulse voltage of the same duration, repetition frequency and polarity as the voltage under test. The amplitude of the rectangular calibration pulses is measured with voltmeter V.

When calibrating, the switch S_1 is first placed in position 2. The amplitude of the calibrating pulse is adjusted with a set limiting level and gain of the oscilloscope so that the top of the rectangular pulse comes in the same place on the screen as that of the differentiated pulse. Next, switch S_1 is turned to position 3 and the decrease of the amplitude is noted. With the knowledge of potential-divider voltage ratio and the amplitude of the calibration pulses it is possible to determine the actual sensitivity ν of the channel (in v/mm).

The measured voltage difference is equal to

$$\Delta U_d = \nu \Delta h. \qquad (15)$$

The deviation from linearity is calculated from (14).

The error of measurement with a correctly chosen time constant of the differentiating circuit τ = RC is determined in the main by the errors with which the values of U_M, T, and τ, which comprise Eq. (14), are measured,

* We have in view only such shapes of saw-tooth voltages where derivative of effective portion changes monotonically. Otherwise the adopted definition (1) of nonlinearity cannot be applied.

by the error of measuring the amplitude of calibrating pulses and the voltage-ratio error of the potential divider r_1-r_2.

The relatively low accuracy with which it is usually required to measure the small deviations from linearity of the saw-tooth voltage is easily attained.

A working model of the above circuit (τ = 2 μsec) in conjunction with oscilloscope 25I provides measurements with an error of 10% of deviations form linearity of the order of 0.05% in saw-tooth voltages with an amplitude of 100 v and duration of 100 μsec. With other saw-tooth voltage parameters the range of deviation measurements changed correspondingly.

The upper frequency limit of the device is determined in practice by the error of differentiating short pulses for a given τ.

For instance if the error of differentiating should not exceed δ_{pr} = 5% from instant t_1 = 0.05 T, it is possible to find on the basis of (11) that $(\tau/T)_{max} \simeq 0.02$ and, hence, with a chosen τ = 2 μsec, T = 100 μsec, i.e., the maximum saw-tooth repetition frequency is equal approximately to 10 kc. For an increased frequency range τ should be decreased.

Above simple device can be used for adjusting and measuring saw-tooth generators, which are one of the main units of automatic measuring instruments based on the transformation of continuous quantities into a discrete form.

S. V. Rypalev participated in the development of above device.

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HIGH AND ULTRAHIGH FREQUENCY MEASUREMENTS

EXPERIMENTAL INVESTIGATION OF A MOLECULAR GENERATOR

A. Ya. Leikin

The molecular generators whose investigation results are given in this article were constructed in the Khar'kov State Institute of Measures and Measuring Instruments in 1956 and 1957.

In both generators the main electrical features developed by N. G. Basov [1] in the P. N. Lebedev Physics Institute of the Academy of Sciences USSR were preserved with a number of constructional modifications. A grid with long channels (1.3-1.5 mm with a diameter of 0.05 mm) was used as a source of the beam.

A system consisting of thick and thin (needle) rods (Fig. 1) is used in order to obtain very smooth tuning of the resonator.

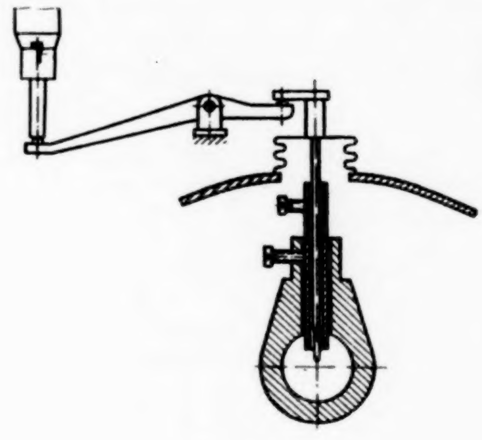

Fig. 1

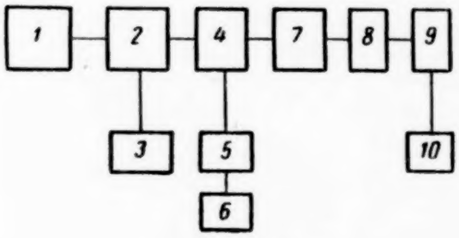

Fig. 2. 1) Ammonia gas-pressure measurement; 2) molecular generator; 3) focusing voltage measurement; 4) mixer; 5) oscillator; 6) source of a saw-tooth voltage; 7) intermediate-frequency amplifier; 8) detector; 9) low-pass filter; 10) tube voltmeter LV-9.

This instrument contains two generators mounted in a common vacuum chamber as does one of the Physics Institute models.

In order to determine the basic characteristics of the generators, the relation of the amplitude and frequency of generation to the tuning of the resonator, ammonia gas pressure at the source of the beam and voltage at the quadrupole capacitor were measured. Measurements of the short- and long-term stability of the generator frequency were also made.

The amplitude of generation was measured by means of an arrangement whose block-schematic is shown in Fig. 2. The relation of the amplitudes of generation to the tuning of the resonator (with the ammonia gas pressure at the source set to $P \simeq 2$ mm Hg and the voltage across the quadrupole capacitor to $U \simeq 32$ kv), to the ammonia gas pressure at the source of the beam (with a certain mean tuning and $U \simeq 32$ kv), and to the voltage across the quadrupole capacitor (same tuning, $P \simeq 2$ mm Hg) were measured. The pressure at the source of the beam was measured by means of a mercury U-shaped manometer connected to the ammonia gas-supply tube at the point of its junction with the body of the generator. Since this manometer provided rough measurements, it was only used for reading the initial, mean and final ammonia gas pressure. Intermediate pressures were expressed in terms of the angle of rotation of the needle valve spindle which controls the ammonia gas input to the source. The variations in frequency of the generator under test with the retuning of its resonator was evaluated by the frequency difference between it and another molecular generator whose tuning, ammonia gas pressure, and voltage across the quadrupole capacitor remained constant.

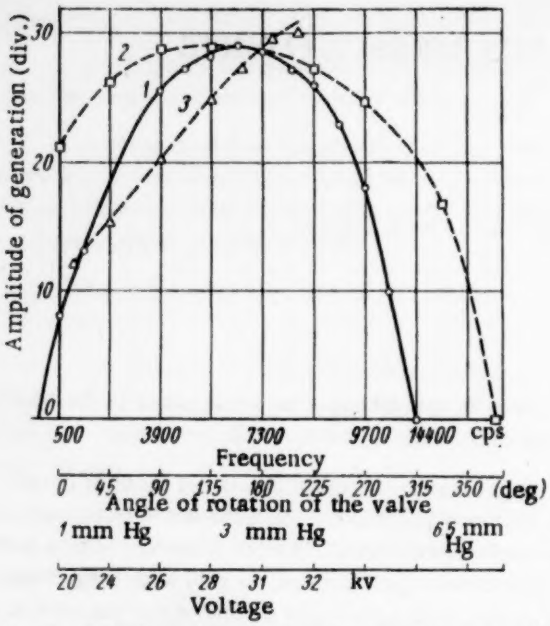

Fig. 3. Relation of the molecular generator amplitude to the tuning of the resonator (1), to the ammonia gas pressure at the source of the beam (2) and to the voltage at the focusing electrodes (3).

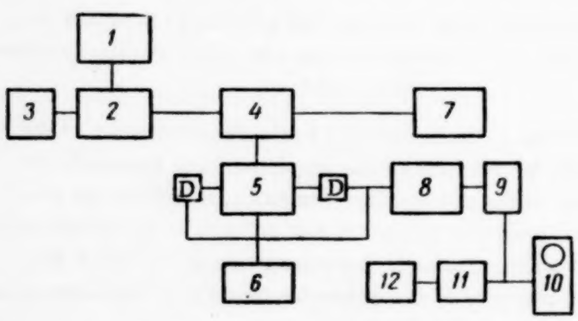

Fig. 4. 1) Focusing-voltage measurement; 2) molecular generator No. 1; 3) ammonia gas pressure measurement; 4) and 5) a second wave-guide T-joint; 6) oscillator; 7) molecular generator No. 2; 8) intermediate-frequency amplifier and second detector; 9) low-pass filter; 10) low-frequency amplifier; 12) counter.

These measurement results are shown in Fig. 3.

It follows from the inspection of curves in Fig. 3 that the amplitude of the generator varies elliptically with respect to the tuning of the resonator. When the ammonia gas pressure is raised at the beam source, the amplitude of generation grows, reaches a maximum and then begins to fall again. The latter circumstance is, probably, due to the defocusing of the molecular beam as the result of the collision of extra molecules supplied to the system. Let us note that both these curves are in good agreement with experimental data [2], obtained for a molecular generator of another design.

When the voltage across the quadrupole capacitor is increased, the amplitude of generator increases at first rapidly and then a little slower.

It follows from the results obtained that the molecular generator operates within a wide range of resonator tuning, ammonia gas pressure and voltage at the quadrupole capacitor.

Generation frequency. The block-schematic of the equipment used for measuring the generator frequency is shown in Fig. 4.

Tests have shown that the variations of the generator frequency bear an almost linear relation to the displacement of the tuning rod. Moreover, the displacement of the thick tuning rod by one division of the microscrew approximately corresponds to a frequency change of 300 cps ($\sim 1\cdot 10^{-8}$ in relative units) and the displacement of the thin rod to some 6 cps ($\sim 3\cdot 10^{-10}$). The tuning range by means of the thick rod amounts to some 11000 cps ($\sim 4.4\cdot 10^{-7}$) and by means of the thin one to some 300 cps ($\sim 1\cdot 10^{-8}$).

An evaluation of the relative stability of the molecular generator was also carried out. For this purpose the beat frequency of two generators was measured. The Q factors of the resonators were respectively $Q_1 = 8000$ and $Q_2 = 5000$. The cooling system was immersed in liquid nitrogen one hour before the beginning of the measurements. In order to prevent the voltage variation across the quadrupole capacitors of the two generators affecting their frequency difference, they were both from the same high-voltage rectifier. The mean frequency variation during 15 seconds amounted to $\sim 1\cdot 10^{-11}$. Variations during one second were of the order of 10^{-13} to 10^{-14}. Measurements over one hour indicated a permanent drift in the frequency. This drift can be explained either by temperature changes (the resonators were not placed in thermostats) or, which is more probable, by variations of the effective density of the beam due to freezing of ammonia in the opening of the cold diaphragm.

It was shown in [3] that the steady state frequency of the molecular generator depends on the amplitude of the steady state resonator oscillations according to the equation

$$\omega=\omega_{tr}\left[1+\frac{2Q}{\omega_0 G(\tau,\gamma)}\cdot\frac{\omega_0-\omega_{tr}}{\omega_{tr}}-\frac{1}{Q\omega_{tr}\,G(\tau,\gamma)}\right]. \quad (1)$$

where ω is the frequency of the molecular generator; ω_{tr} is the transition frequency; ω_0 is the resonator frequency; Q is the resonator's quality factor; $G(\tau, \gamma)$ is a function of the amplitude of oscillations which in turn depends on the number of active molecules.

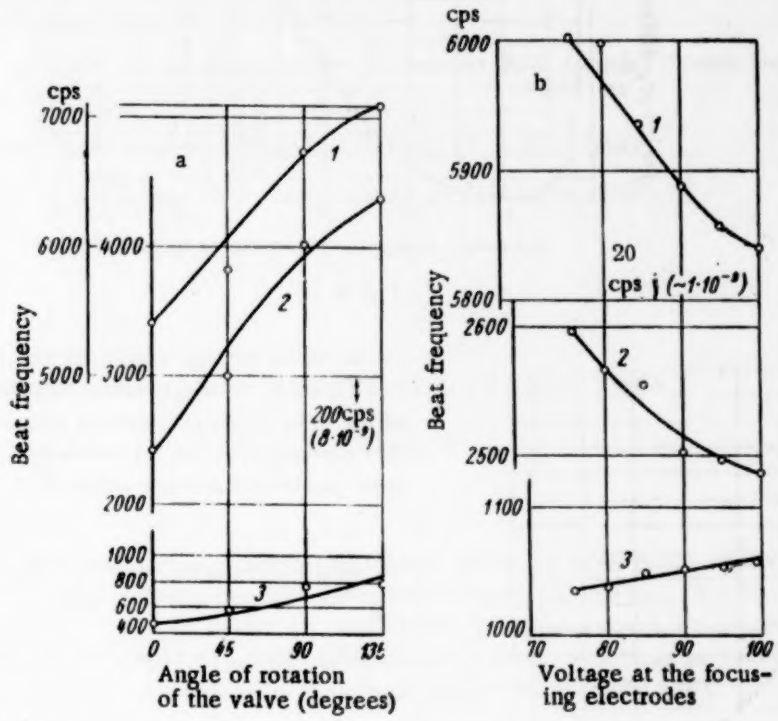

Fig. 5. a) Generator-frequency variations with changes in the ammonia gas pressure; resonator tuning: 1) 3.00 divisions of microscrew; 2) 3.25 divisions; 3) 3.15 divisions. b) Generator-frequency variations with changes in voltage across the focusing electrodes; resonator tuning: 1) 3.00 micrometer screw divisions; 2) 3.75 divisions; 3) 3.15 divisions.

The number of active molecules depends on the method of grading and the intensity of the molecular beam, hence, the frequency of the molecular generator will, in general, depend on the ammonia gas pressure, P_a at the source of the beam and on the voltage U_q at the quadrupole capacitor. From (1) it follows, however, that there exists a tuning of the resonator [4, 5] at which the frequency of the generator does not depend on $G(\tau, \gamma)$ and is equal to the transition frequency.

With this tuning

$$\frac{\partial f_g}{\partial P_a}=0, \quad \frac{\partial f_g}{\partial U_q}=0. \qquad (2)$$

For an experimental investigation of this proposition the relation of the generator frequency to the ammonia gas pressure and to the voltage across the focusing electrodes was determined.

Fig. 5,a shows generator-frequency measurements with a rising ammonia gas pressure from 1.5 to 5 mm Hg (the pressures are expressed as previously in terms of the needle-valve stem angle of rotation), Fig. 5,b shows the same measurements with a variation of the focusing voltage from 20 to 32 kv for three fixed tuning positions of the resonator: at the extremes and in the middle of the generating range. It follows from the inspection of Fig. 5 that variations of the generation frequency with changes in the ammonia gas pressure and the focusing voltage depend to a great extent on the tuning of the resonator. In fact for the resonator tuning corresponding to 3.25 divisions of the microscrew (one of the extreme tuning positions) the maximum frequency changes, within the stated limits of ammonia gas-pressure variations, amount to ΔF_m = 2000 cps ($\sim 8 \cdot 10^{-8}$) and within the stated

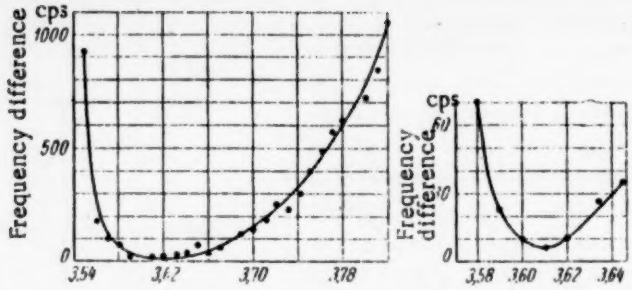

Fig. 6

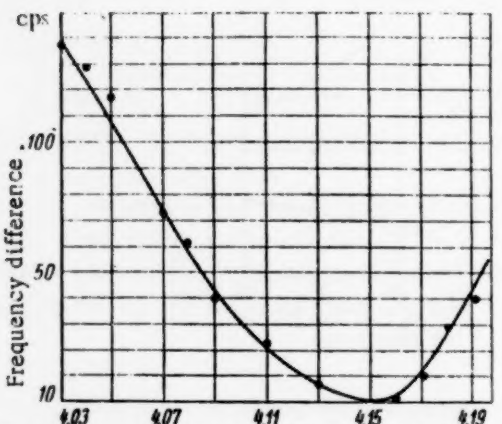

Fig. 7

limits of the voltage variations to $\Delta F'_m \approx 110$ cps ($\sim 5 \cdot 10^{-9}$); for a resonator tuning corresponding to 3.00 divisions of the microscrew (the second extreme tuning point) and for that corresponding to 3.15 divisions (the middle tuning), these deviations amount respectively to

$$\Delta F_m \simeq 1700 \text{ cps } (\sim 7 \cdot 10^{-8}), \; \Delta F'_m \sim 170 \text{ cps } (\sim 7 \cdot 10^{-9})$$

and

$$\Delta F_m \simeq 310 \text{ cps } (\sim 1.9 \cdot 10^{-8}), \; \Delta F'_m = 25 \text{ cps} (\sim 1 \cdot 10^{-9}).$$

These curves show that in fact there exists a tuning for which the generator frequency is independent, or more precisely little dependent on the parameters of the beam. In order to find this tuning, beat frequencies were measured for two values of ammonia gas pressure and focusing voltage over a wide range of tuning-rod displacements. These measurements are shown in Fig. 6 (for ammonia gas-pressure variations) and Fig. 7 (for focusing-voltage variations).

Both curves have pronounced minima of frequency variations. It will be seen from curves in Figs. 5, 6, and 7 that changes in the ammonia gas pressure affect the generating frequency to a much larger extent than changes in the focusing element voltages. Repeated tests have shown that the minima of the two curves, i.e., tuning values corresponding to $\partial f_g/\partial P_a = 0$ and $\partial f_g/\partial U_q = 0$ do not coincide. The difference between the minima varied from $\sim 5 \cdot 10^{-9}$ to $\sim 1 \cdot 10^{-8}$. If, however, the resonator is tuned to an optimum for variations in the ammonia gas pressure, changes in the focusing voltage between 20 and 32 kv will not vary the generating frequency by more than 5 cps or $\sim 2 \cdot 10^{-10}$. Since under operating conditions it is not difficult to maintain a constant voltage at the focusing electrodes within 2-3%, tuning of the generator for optimum conditions with respect to ammonia gas pressure variations can be carried out with precision.

CONCLUSIONS

Tests have shown that above molecular generator has a highly stable frequency and good operational properties. For any given absolute frequency the resonator should be tuned with respect to variations in the ammonia gas pressure. The accuracy of the absolute frequency of a molecular generator obtained by this means and the effect of various factors on it will be further investigated.

A. I. Samoilovich participated in designing our molecular generator model, he also suggested the technique and carried out the construction of the grid with long channels. M.I. Klyus took part in the construction of the generator and E. Z. Orlov in the tests described above.

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VISUAL CHARACTERISTIC-CURVE TRACER FOR TRANSISTORS

E. P. Bochkarev

The measurement of parameters of transistors, electronic tubes and other nonlinear elements is of great importance for the manufacture and adjustment of various radio-technical devices. A display method of plotting nonlinear element volt-ampere characteristics, from which the parameters of the elements can be determined at various operating points, is labor-saving and sufficiently accurate both for laboratory investigations of the quality of various nonlinear elements and for their mass-production checking and grading under workshop conditions.

In order to plot a volt-ampere characteristic of a two-electrode nonlinear element it is necessary to supply it with a saw-tooth voltage and feed the oscillograph vertical and horizontal amplifiers, respectively, with the voltage impressed on the element under test and a voltage directly proportional to the current flowing through the element. In order to obtain a family of curves of a nonlinear element with three electrodes, it is necessary to impress on the third electrode, whose voltage or current is a parameter of the element, a stepped voltage. For instance, in order to obtain the characteristic family of curves of a transistor,

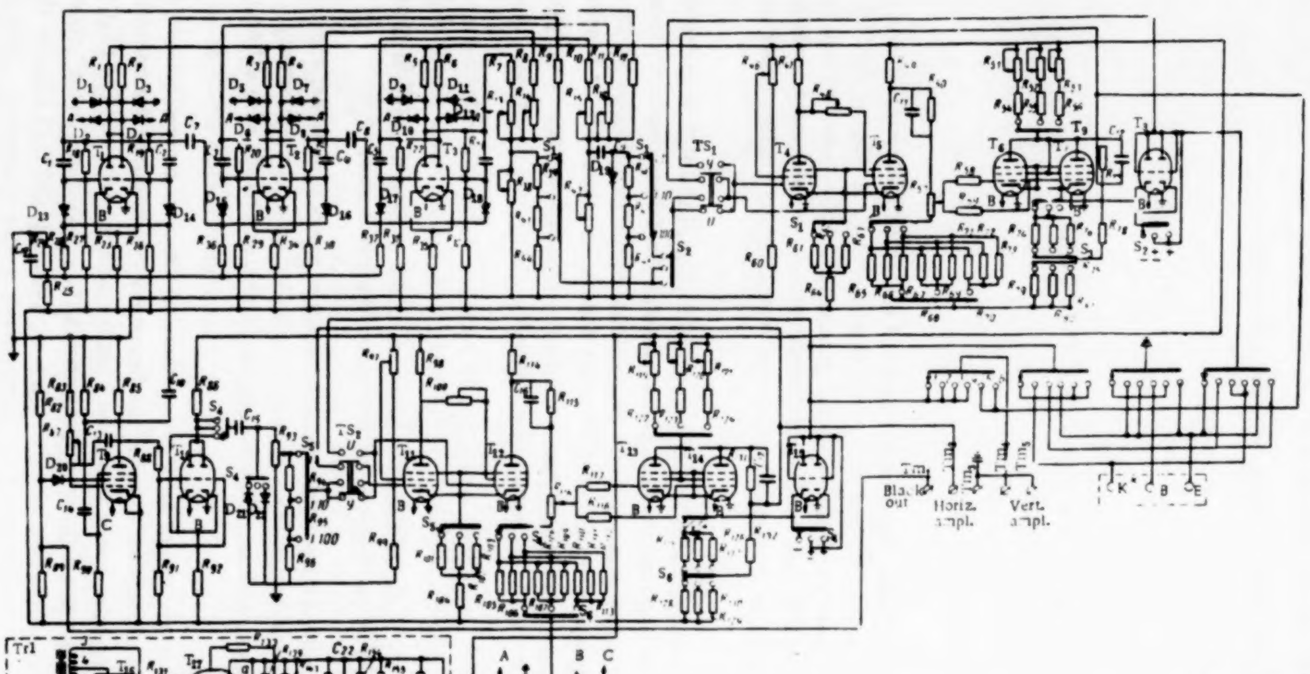
$$U_k = f(I_k);\ I_e = \text{const},$$

where U_k is the voltage at the collector, I_k is the collector current, I_e is the emitter current, it is necessary to feed to the collector the signal voltage and to the emitter the voltage of the parameter.

The curve tracer in question can be used for plotting characteristics of various nonlinear elements. It is possible to observe on the screen of oscillograph type ÉO-7, or another similar type, simultaneously a family of 8 characteristic curves, such as output, input, mutual, static and dynamic characteristics with different voltage and current scales.

Figure 1 shows the schematic of the curve tracer for plotting characteristics of three-electrode elements. The saw-tooth master oscillator provides a voltage of 400 pps. Its frequency synchronizes the operation of the remaining stages of the instrument. The oscillator is a transitron circuit operating with a 6Zh4 (T_9) pentode. The signal is fed from the screen grid through the differentiating network (C_{16}, R_{26}) to the "step" generator, for the purpose of starting and synchronizing its operation, and through a crystal diode DGTs-7 (D_{20}) to the "blackout" terminal, to which the brightness control electrode of the oscillograph is also connected. Thus, the oscillograph spot is blacked out on flyback. The oscillator frequency is controlled by means of potentiometer R_{87}. Frequency F = 400 pps was chosen to provide on the one hand a picture without flickering and on the other to avoid all types of pickup which occur at higher frequencies.

The amplifier stage consisting of a 6N8 (T_{10}) tube serves to provide a "rising" or "falling" saw-tooth voltage, since it is possible by means of switch S_4 to take signal either from the anode or cathode of T_{10}. The amplitude



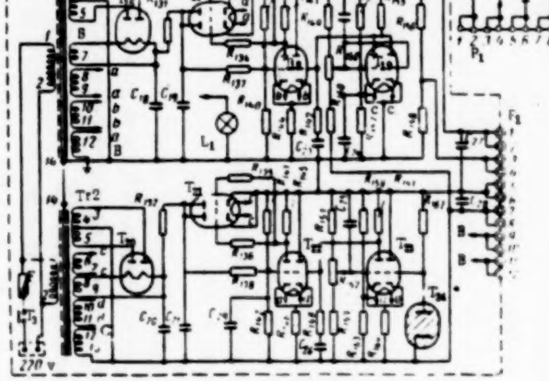


Fig. 1

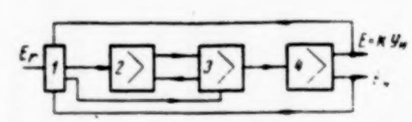


Fig. 2. 1) "Generator–voltage generator" switch; 2) and 3) differential amplifier; 4) power amplifier.

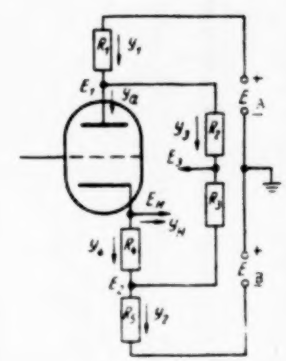


Fig. 3

of the "rising saw-tooth" voltage, taken from the anode, is equal to 200 v, and of the "falling" voltage, taken from the cathode, to −100 v.

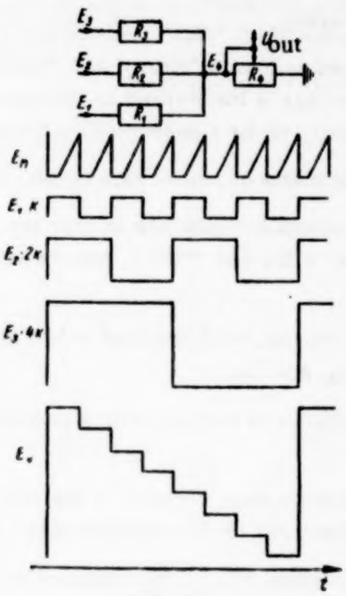


Fig. 4

Diodes DGTs-7 (D_{21} and D_{22}) serve to start the saw-tooth from zero potential. From the attenuator, consisting of potentiometer R_{93} and resistors R_{94}, R_{95}, and R_{96}, the signal is fed to the current or voltage saw-tooth generator, whose block schematic is shown in Fig. 2.

The generator consists of the following system with a powerful output. A differential amplifier consisting of two 6Zh4 (T_{11} and T_{12}) tubes with a positive feedback between the anode of T_{11} and the screen grid of T_{12}.

This amplifier tends to reduce to zero the difference between the voltages fed to the control grids of T_{11} and T_{12}. By means of appropriate adjustments (R_{100}, R_{97}, etc.) it is possible to attain a very small difference between the two voltages in the range of ± 100 v. From potentiometer R_{116} the signal is supplied to the powerful output stage, consisting of two 6P9 (T_{13}, T_{14}) tubes connected in parallel. In position U of tumbler switch TS_2 the control grids of T_{11} and T_{12} receive, respectively, voltages from the attenuator and the output of the tracking system, which operates as a constant voltage generator, i.e., with a very small output impedance. In position Y of tumbler switch TS_2 the control grids of T_{11} and T_{12} receive, respectively, voltages from the midpoint of potential divider R_{131}, R_{132} and the attenuator. The tracking system now operates as a constant current generator, i.e., its output impedance is very large and the output stage operates as a load-current calibrator as well (Fig. 3).

For $R_1 = R_5$; $R_2 = R_3$; and $E_A = -E_B$ we have

$$I_1 = I_a + I_8 = I_4 + I_n + I_3; \tag{1}$$

$$I_2 = I_4 + I_3; \tag{2}$$

$$E_3 = \frac{E_1 + E_2}{2} = \frac{E_A - R_1 I_1 + E_B + R_5 I_2}{2}. \tag{3}$$

By substituting (1) and (2) in (3) we obtain

$$E_3 = \frac{E_A - R_1(I_4 + I_n + I_3) + E_B + R_5(I_4 + I_3)}{2} = -\frac{R_1 I_n}{2}. \tag{4}$$

Hence E_3 is directly proportional to the load current and by changing R_1 it becomes possible to change the scale of the load current. Potentiometers R_{119}-R_{121} serve to obtain the equality $R_1 = R_5$ and equality $E_A = -E_B$ is attained by adjusting the electronic stabilizers.

Switch S_6 serves to change the load current. Switch S_4 changes the polarity of the output voltage. When the polarity is negative the signal is fed to the element under test through tube 6N8 (T_{15}) connected as a diode.

The step-voltage generator is designed to supply the parameter voltage and consists of three relaxation bistable circuits. Figure 4 shows the "steps" obtained and the schematic of the summator. In order to obtain a stable output voltage for all the relay circuits, crystal diodes DGTs-7 (D_1-D_{12}) are connected into their anode circuits (T_1, T_2, and T_3). The amplitude of the rectangular voltage is equal to 100 v.

For $R_1 = 2R_2 = 4R_3 = 200$ kilohm, $R_4 = 22$ kilohm, and $E_1 = E_2 = E_3 = 100$ v, and assuming that $R_3 \gg R_4$ the value of each step is:

$$E_{step} = \frac{E_1 R_4}{R_1 + R_4} = \frac{100 \cdot 22}{200 \cdot 22} = 9.9 \text{ v}. \tag{5}$$

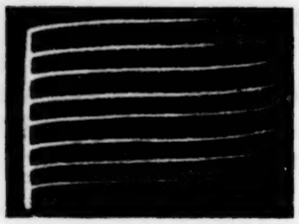


Fig. 5

Since condition $R_3 \gg R_4$ is not fully fulfilled, adjusting potentiometers R_{14}-R_{16} are incorporated in the instrument and serve to obtain an equality of step voltages with a sufficient degree of accuracy.

Two summators and attenuators are used to obtain "rising" and "falling" steps. From the attenuator the parameter voltage is transmitted to the current or voltage generator (T_4-T_8), designed similarly to the signal-tracking system.

The instrument has the following adjustments of output parameters.

By means of step and continuous attenuators, it is possible to vary the amplitude of the saw-tooth voltage from 0 to +200 and −100 v, and the step voltage from 0 to +75 v.

Switches S_3 and S_6 are designed to select ranges of the load current from 0-1 ma, 0-10 ma, and 0-100 ma. A smooth adjustment of the load current is made by means of attenuators R_{38}, R_{43}, and R_{93}.

Switch S_7 serves to select the required transistor characteristic (input, output, and mutual, with a grounded base or grounded emitter).

By means of tumbler switches TS_1 and TS_2 it is possible to select, as the independent variable of the characteristic being plotted, either the current or the voltage of the corresponding electrode of the element under test.

It is possible to calibrate the sensitivity of the vertical and horizontal amplifiers of ÉO-7 by means of the calibrating signal of the oscillator itself, having measured its amplitude beforehand; moreover for calibrating the horizontal amplifier the calibrating signal terminal should be connected to the horizontal amplifier terminal and its characteristic measured; its sensitivity should be mm/v = F (the position of the continuously variable attenuator of the horizontal amplifier).

The vertical amplifier is calibrated similarly.

For instance, if it is required to plot the output characteristic of transistor P2 with a grounded base $U_k = F(I_k)$, I_e = const with variations in U_k from 0 to −50 v and of I_k, I_e from 0-10 ma. It is necessary to: 1) throw switch TS_1 to position "Y"; switch S_5 to "1 : 1"; S_2 to "+"; S_3 and S_6 to the middle position; S_4 to "−"; S_7 to "1"; TS_2 to "U"; R_{38} and R_{93} to "0"; 2) connect the oscillograph to terminals Tm_1-Tm_5, set the vertical amplifier's attenuator, variable between 0 and 50 v and supplied with U_k, to a position corresponding to a sensitivity of 1.6 mm/v (the vertical sweep of the screen is equal to 80 mm); and set the attenuator of the horizontal amplifier to 2 mm/v, since the horizontal amplifier is fed with voltage $E_3 = -R_1I_H/2 = 8 \cdot 10^3 \cdot 10 \cdot 10^{-3}/2 = 40$ v. In Fig. 4 R_1 corresponds to $R_{120} + R_{123} = R_{129} = 8$ kilohm; $I_H = I_{k\,max} = 10$ ma (see Fig. 4 and the schematic). The sweep of the horizontal amplifier screen will then be equal to 80 mm; 3) connect the transistor under test; 4) by means of R_{38} and R_{93} adjust the dimensions of the characteristic curves to be measured vertically and horizontally to 80 mm (judged by the grating of the screen). The value of I_e is determined similarly to I_k and is controlled by means of R_{38}.

Figure 5 shows the output characteristic curves of transistor type P2A taken by means of a model of the instrument.

In plotting the characteristics of two-electrode nonlinear elements (crystal or thermionic diodes, nonlinear resistances, etc.) only the saw-tooth oscillator and its current or voltage generator operate in the circuit.

Characteristics of low-power thermionic triodes and pentodes can also be plotted providing small changes are made in the design of the instrument.

The instrument's supply circuit consists of two rectifiers and two electronic stabilizers for +300 v and −300 v. The consumption does not exceed 250 w.

The equipment consists of two parts, namely measuring instrument and the power pack.

Tests of the instrument model provided satisfactory results.

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NEW END-TYPE LENGTH-MEASURING MACHINES

A. V. Érvais

End-measurement machines are widely used for measuring lengths in the engineering industry both at home and abroad. They are usually made with the upper measuring limit of 6000 mm. Our industry also employs machines designated by various institutes (VNIIM, MIIGAIK) and plants for measuring lengths up to 12000 and 24000 mm. At present there are several types of measuring machines used by our industry. Firms abroad have made such machines to various designs. Some of them are not widely used here due to their poor metrological properties and operation facilities, others due to the fact that they have not been sufficiently studied. Below we give a description of certain efficient measuring machines of a new design.

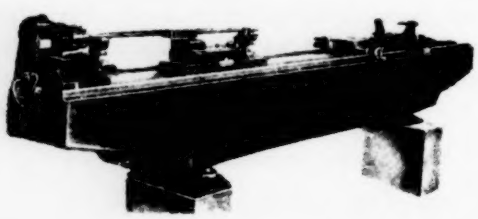


Fig. 1

"Zeiss" (GDR) measuring machine. The Zeiss Company now produces new end-measurement machines (Fig. 1) whose range of application is considerably wider than that of the old models. The new machine can measure both internal and external dimensions of articles with plane-parallel, spherical and cylindrical surfaces, threads of thread gages by the projection method and by means of wires (d_{av}), the pitch and profile of guide-screw threads, the pitch and profile of gear-rack gears, linear measures, etc.

The linear measures are compared with a precision linear scale incorporated in the instrument.

The instrument stand has two pairs of guide rails. One pair carries the measuring device and the other the article being measured. This provides the facility of moving the measuring device along the measured object.

The machine is provided with an optical and mechanical reading device. Measurement can be made by means of contact and noncontact, axial section or shadow methods.

A standard guide screw is attached to the equipment by means of an adapter. The checking of guide screws is made by means of a measuring nose with a spherical contact surface. Measurements can be made both on the left and right-hand-side profile of the thread. Moreover, the error of the pitch can be checked at any portion of the tested screw, within the limits of one pitch or as an accumulated error for any desired section.

The internal error is determined by means of a reference polyhedron with 12 highly polished faces. The polyhedron is fixed to the article under test and used in conjunction with a collimator, which has an eyepiece micrometer with a scale division of 0.5" for determining the angle of rotation of the polyhedron. This device is not affected by the skewing of the instrument carriages.

The linear measure incorporated in the machine has 0.1 mm divisions, the microne graduations are obtained in absolute measurements by means of an optical-wedge micrometer and in relative measurements by means of the telescope caliper graduations.

The machine stand rests (according to normal practice) on three feet, one being fixed and the other two adjustable. The adjustment of the optical devices of the instrument is concentrated at one place of the stand. The machine is placed on a massive table with a floating working surface, transverse pointed journals with micrometer adjustment and blade bearers (supports).

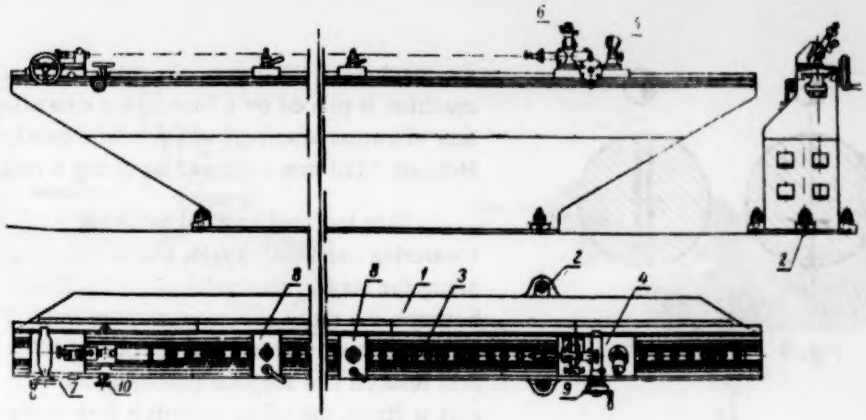


Fig. 2. 1) Stand; 2) set bolts; 3) decimeter scale; 4) measuring carriage; 5) double-image eyepiece head; 6) measuring microscope with a helical eyepiece micrometer; 7) flywheel drive for the tail spindle head of the measuring carriage; 8) carriers (roller supports); 9) flywheel drive for rough and precise adjustment of the carriage, 4; 10) flywheel drive for lifting the universal object table.

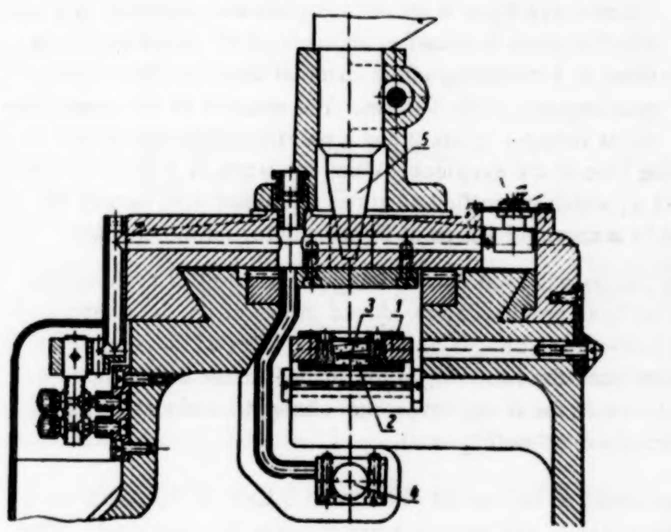


Fig. 2

This machine is more universally applicable than the one previously made. We have no experience in operating this machine. Its error of measurement is similar to that of conventional machines.

Technical characteristics of the "Zeiss" measuring machine. Minimum graduations of the metallic scale are 1 mm, of the glass scale – 0.1 mm, of the optical micrometer – 0.001 mm, of the optical goniometric head – 1' and of the optical capstan head – 10'. Range of measurement of external dimensions of linear measures and pitches 0-3000 mm, and of internal dimensions 30-2850 mm. The largest internal diameter measurable on the large table is 350 mm. The largest measurable diameter of a guide screw is 100 mm. The measuring effort in external and internal measurements is 200± 50 g.

The new design of the "Zeiss" measuring machine is an improvement on the old one and its range of measurement has been considerably extended. Especially, important is the possibility of checking, by means of it, guide screw threads, since there is a lack of such measuring instruments.

Siemens-Schuckert measuring machine. The end-measurement machine of original design, developed and manufactured by Siemens-Schuckert for measuring lengths from 0 to 6000 mm is of considerable interest. The machine incorporates standard optical instruments of the Zeiss, Leitz and other companies. The error due to the infringement of the Abbé comparison principle is reduced by decreasing as far as possible the distance from the plane of the decimeter scale to the axis of measurement, by careful construction of the stand guiding rails, a prolonged ageing of the stand, increasing the length of the bearing surface of the measuring carriage in order to avoid possible strains and by high-quality production of all the important components of the machine. Owing to the above the metrological characteristic of the machine is in no way inferior to that of machines with an optical compensator of the error due to the infringement of the Abbé principle (for instance the Zeiss machine).

The Siemens-Schuckert machine (Fig. 2) has a solid stand resting on three adjustable feet. The distance between the feet in the longitudinal direction is 4540 mm, in the transverse direction 600 mm; the total length of

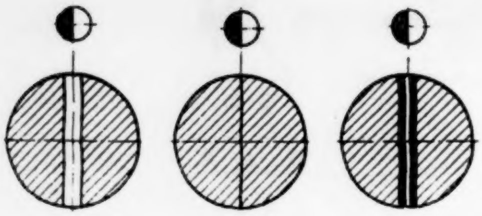


Fig. 4

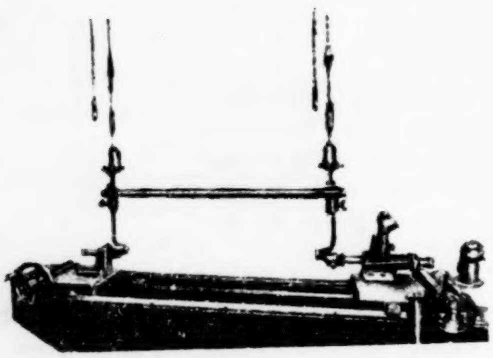


Fig. 5

the machine is 7200 mm. In order to avoid vibration, the machine is placed on a foundation consisting of plates with four vibration absorbers which hold a reinforced concrete H-beam 2120 mm high and weighing 8 tons.

Two inclined toothed racks (m = 3), along which the measuring carriage travels, are placed in the middle of and along the stand guide-rails. The decimeter scale is placed between the racks and consists of six rules 1 (Fig. 3) each 1000 mm long with a cross section of 14 × 70 mm. Each rule rests on two supports placed in the Airy points. One support is fixed, the other permits a free movement of the rule caused by variations of the ambient air temperature.

The decimeter rule has at each 100 mm an opening 38 mm in diameter filled with glass plates 2 (the decimeter eye).

Half of the area of the glass plates is covered with a black, opaque layer of lacquer. The edge of the layer passes precisely through the diameter of the plate. Over each decimeter eye there is an adjusting device consisting of a plane-parallel plate 3 placed at an angle of 5°. Glass plate 3 is fixed in a mounting whose external diameter has a worm-gear engaging with a worm. The rotation of the worm produces tilting of plate 3 and a parallel displacement of the decimeter-indicator image with respect to the sighting line of the eyepiece. When the worm is rotated through half a turn, the decimeter indicator is displaced by 3 μ, which magnified 40 times represents 0.12 mm in the field of vision. The decimeter eyes are illuminated by a movable source of light mounted on the carriage.

The tube of the sighting microscope 5 (Fig. 3) carries a normal double image head (similar to those supplied with measuring and universal microscopes). This head provides a reproduced image of the decimeter indicator, i.e., in the field of vision there appear two half-shaded images of the sighting sides of the decimeter eye (Fig. 4,a). When the measuring microscope is displaced the two sides of the shaded image either move toward or away from each other. When the two images touch, the shade covers the whole field of vision (Fig. 4,b). If the microscope is moved still further the shaded images overlap (Fig. 4,c).

The sighting of the decimeter indicator is considered to be correct when the two half-shades touch each other without overlapping (without a black line being visible), and without a gap showing between them. This method provides a high sensitivity and accuracy of sighting.

The dispersion of readings with repeated superposition of the half-shades does not exceed 0.3-0.5 μ.

In addition to the sighting microscope the carriage also carries a measuring device which provides the reading of millimeter and centimeter distances as well as hundredths and thousands of a millimeter. The measuring unit of a normal optical horizontal (or vertical) distance gage is used in the machine for this purpose.

The carriage is displaced by means of planetary transmission, which provides a rough and precise adjustment without using additional parts. The device is operated manually through a friction claw-clutch by rotating the shift ring which has an internal geared drive and is situated behind the planetary transmission.

The principle of the device consists in connecting the central planetary-transmission gear wheel to the body of the carriage (for fine adjustment) or to the planetary transmission box (for rough setting).

Articles up to 300 mm long are placed on the universal object table and those between 300 mm and 1000 mm on roller supports. The table and the supports are normal components of Soviet and Zeiss measuring machines.

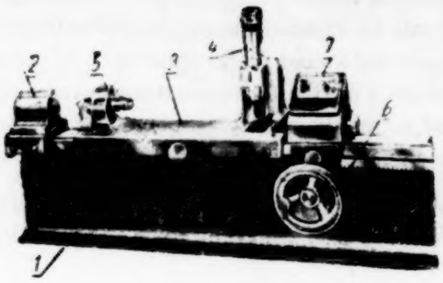


Fig. 6

Fig. 7

TABLE 1

Measured length, mm	Number of supports under the measured article	Number of supports under the stand	Measured length, mm	Number of supports under the measured article	Number of supports under the stand
Up to 3000	2	2	Up to 7000	6	4
Up to 4000	3	2	Up to 8000	7	4
Up to 5000	4	3	Up to 9000	8	4
Up to 6000	5	3	Up to 10000	9	5

For articles over 3000 mm a suspension device is provided which reduces the error of measurement due to the greater weight of the article.

The machine is provided with a device for internal measurements. It consists of two extension pieces fixed to the tail spindle and the measuring tube (Fig. 5). The extensions are 45 mm higher than the measuring axis for external dimensions. In the device for internal measurements the direction of the measuring effort is reversed as compared with the external measurements.

The peculiarity of this machine consists in making the light beam travel over relatively short distances only, thus avoiding errors due to the optical irregularities of the air (heating, movement or congestion of air). This arrangement requires, however, very accurate stand guides.

According to the manufacturer's data the total error of reading for this machine amounts to

$$\delta = (0{,}8 + 6L + 0.45L^2)\ \mu$$

where L is the measured length, m.

The error of measurement, according to the same information, does not exceed

$$\delta = \pm\,(1{,}3 + 9{,}3L + 0.7L^2)\ \mu$$

The construction of the Siemens-Schuckert measuring machine is of considerable interest, since it has been made in a nonspecialized plant, and it uses standard components of mass-produced measuring instruments. The measuring element of a normal optical distance gage was first used as a sighting device on the end-type measuring machine for lengths up to 12000 mm, designed by the D. I. Mendeleev All-Union Scientific Research Institute of Metrology.

The utilization by the VNIIM, Siemens-Schuckert and other manufacturers (see below) of an optical distance-gage measuring head in measuring machines confirms the advisability of such a design of measuring machines.

The use of double-image head for sighting, the new design of the adjustable decimeter eyes, etc., deserve attention in the Siemens-Schuckert measuring machine.

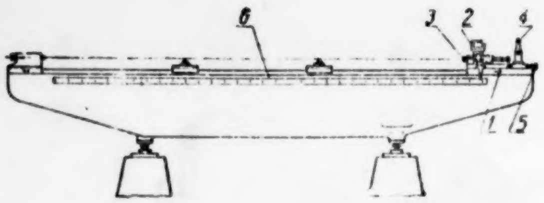


Fig. 8

The advisability of equipping our machines with such elements should be considered. The design of components for internal measurements remains very inadequate and should be reconsidered. It is advisable to introduce a device for internal measurements by means of a "magic eye" as employed by the Zeiss company, and adopted by several plants for their own needs.

Measuring machines of the Hommel-Werke company (FGR) are very simple in their design. The majority

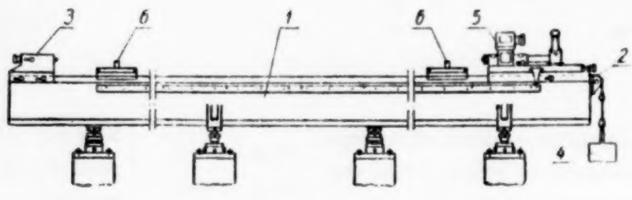


Fig. 9

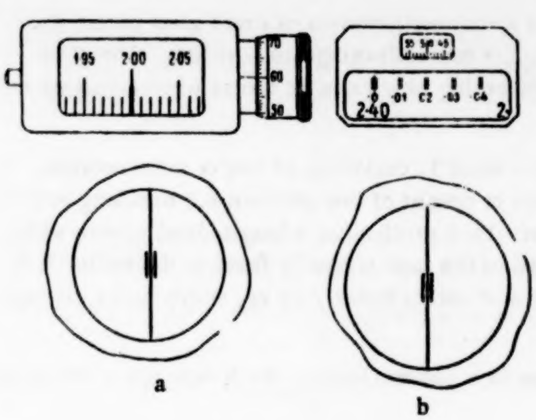
TABLE 2

Nominal size, m	Errors of measurement on machines, μ						
	Siemens-Schuckert	Zeiss		Hommel-Werke			
		absolute method	comparative method	external dimensions		internal dimensions	
				abs.	rel .	abs.	rel .
1	2	3	4	5	6	7	8
1	12	11	5.5	20	9	26	12
2	24	21	10.5	30	15	37	19
3	36	31	15.5	40	21	48	26
4	50	41	20.5	50	27	59	33
5	66	51	25.5	60	33	70	40
6	84	61	30.5	70	39	80	47

of this type of instrument should be called "measuring devices". Their foundation, as a rule, consists of an H beam whose upper surface has rectangular guides which carry the measuring components and supports for the measured article.

Similar equipment, based on an H-beam, cast-iron bridges, etc., has been made by plants which produce large components. This equipment, however, has a larger measuring error than the normal optical end-type measuring machines, which have more accurate scales and measuring devices with compensation for errors due to the infringement of the Abbe principle. The Hommel-Werke equipment is normally used, therefore, in workshops for checking and setting inside calipers and snap gages, etc.

Figure 6 shows a precision end-type measuring machine of the Hommel-Werke company. Stand 1 (an H-beam) carries a fixed head 2 and a carriage 3. A measuring microscope 4 with a magnification of 12.4 diameters and a micrometer element 5 with 0.002 mm graduations and a range of 0-13 mm are mounted on the carriage. A precision scale with centimeter divisions is placed between the stand guides and observed by means of reflected light in the eyepiece of microscope 4. A glass plate with a bisecting line which is made to coincide with the graduations of the scale is placed in the field of vision of the eyepiece. The displacement of the measuring carriage 3 for setting the machine to a certain dimension is first made by means of flywheel drive 6 and the final



a b

Fig. 10

TABLE 3

Measuring range, mm	Total error, μ
0-100	1.5
100-300	2.5
300-900	5.0
900-1500	7.5
1500-3000	12.5

adjustment with an adjusting screw mounted on the carriage. Accurate zero setting and a constant measuring effort are ensured by means of a pointer device 7, connected electrically to the measuring rod of head 2. The measuring-device pointer reacts to the slightest pressure on the working surfaces of the backstock and carriage measuring rods due to a contact between them and the measured article.

External measurements are taken normally and the internal ones with the aid of block gages and clamps (Fig. 7). The company recommends placing the following number of supports (Table 1), according to the range of the machine and the length of the measured article.

Plants using measuring equipment are advised to produce measuring machines of the Hommel-Werke type themselves and use them for testing under workshop conditions with an accuracy which is relatively low, but sufficient for many production measurements. The electrically operated measuring device is of interest; it provides measurements with a small effort. The design of this device is unknown, but it is not likely to be complicated.

Errors of measurement of the described machines and their comparison is given in Table 2.

These errors have been calculated from the following formulas and expressed in microns:

for column 2 $\pm(1{,}3+9{,}5L+0{,}7L^2)$,
» » 3 $\pm(0{,}5+10L)$,
» » 4 $\pm(0{,}5+5L)$,
» » 5 $\pm(10+10L)$,
» » 6 $\pm(3+6L)$,
» » 7 $\pm(15+11L)$,
» » 8 $\pm(5+7L)$,

where L is the measured length, m.

Measuring machine of the Hilger and Watts Company (England). Hilger and Watts produce measuring machines of two types, those with a range of 0-2000 and 0-3000 mm and graduation of 0.001 mm, and others with a range of 0-8000 mm and graduation of 0.002 mm.

The machines of the first type (Fig. 8) combine, to a certain extent, features of the Siemens-Schuckert and some of the elements of Soviet and Zeiss machines (of the earlier types).

The Hilger and Watts measuring carriage has the same carriage 1 as the Siemens-Schuckert machine, but instead of using a helical optical micrometer for reading the millimetric scale, it is displayed on a screen 2 equipped with an optical micrometer which provides readings of fractions of a micron (0.25 μ). A constant measuring effort is ensured by means of a spring drum connected to the measuring tail spindle 3.

The images of the decimeter graduations are sighted by means of microscope 4 with a magnification of 60, the bisecting microscope lines are made to coincide with the decimeter graduations by means of the micrometer drive head 5.

The face side of the machine carries a meter scale 6 graduated at every 100 mm and serving for an approximate adjustment to decimeter graduations; a more precise setting is made by means of microscope 4. The basic

meter scale of the machine (similarly to the Siemens-Schuckert instrument) consists of round glass plates fixed in a special rule. The rule is mounted on two rollers placed in the most advantageous positions. The glass plates with the decimeter graduations are fixed at an angle in mounting which can be turned when adjusting the decimeter scale by means of block gages.

The second type of machine (Fig. 9) is based on a cast iron stand 1, consisting of two or more sections. The dimensions of the sections can be, for instance, 3, 2, and 1.8 mm or consist of two sections 3.2 mm long and one 1.8 mm section. These sections abut accurately with each other. Each section has a longitudinal groove which holds tape 2 accurately calibrated at 100 mm intervals. One end of the tape is rigidly fixed to the tailstock 3, the other is taken over a low friction pulley and fixed to weight 4 of approximately 10 kg, which keeps the tape taut.

The error in tape graduation does not exceed ± 0.0025 mm in a 100 mm length. Each tape has a certificate attached to it.

The stand carries measuring elements similar in construction to those of the machine of the first type. Projector 5 of measuring carriage 6 has a screw-type eyepiece micrometer 7 with thimble graduations of 0.002 mm and a sighting microscope 8 with a magnification of 30. The field of vision of the projectors and microscopes of the machines of the first and second type are shown in Fig. 10. The scale combination shown in Fig. 10,a in inches amounts to a reading of 2.0060". The combination shown for the machine of the first type (also in inches) amounts to 2.405" (Fig. 10,b). These scales can be also graduated in the metric system. In this case the large figures at the bottom denote millimeters, the middle scale is calibrated in tenths of a millimeter and the upper scale in microns, divided in half by a short line. Thus, 0.5 μ can be read and 0.25 μ estimated.

According to the data of the Hilger and Watts Company, the error of readings of machines of the first type lies within the following limits (Table 3).

The mean total error of the machine can be expressed by the formula $\delta = (0.5 + 5L)\ \mu$.

The Hilger and Watts measuring machines have a number of features which it is advisable to use in our existing and projected measuring machines. These features include the use of screens in conjunction with optical or screw micrometers instead of optical heads; this facilitates reading and increases its accuracy; the use of an adjustable spring attached to the measuring tail spindle, and other features. The use of a calibrated steel tape deserves attention, but this requires further study.

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INFORMATION

THE FIRST CONFERENCE OF THE SCIENTIFIC AND TECHNICAL SOCIETY OF THE INSTRUMENT-MAKING INDUSTRY

A. I. Chinarev

The first conference of the Scientific and Technical Society of the Instrument-Making Industry took place in Moscow on May 15-16, 1959. The conference was attended by 109 delegates from 231 basic organizations of the society grouped in 14 Republic and Regional Administrations of the Society.

The president of the Central Administration, Dr. Tech. Sci. Prof. A. N. Gavrilov noted, in the report of the administration which he presented, the work of the Society members and its branches in discussing suggestions and working out proposals for the development of Soviet instrument-making, and the implementation of the historic decisions of the CPSU 21st Congress. The basic organizations of the "Tochomskpribor", "Niichasprom" and other plants were the most active. In the last three years 26 competitions were organized with the participation of 1194 people; of the 522 papers submitted, 237 were awarded prizes; the majority of the most efficient proposals were implemented by scientists and engineers in cooperation with the innovators of production.

Experiences were exchanged both inside our country and with foreign countries. The Scientific and Technical Society of the Instrument-Making Industry, represented the USSR at the first International Metrological Conference in Budapest in 1958.

Delegates to the Moscow conference described the state of instrument making in the republics and industrial centers and made suggestions for the improvement of the Society's work.

Many instances were also noted of weak control over the implementation of the proposals made by the Society members, insufficient assistance from Scientific, Technical and Design organizations and Training Institutes to the industrial organizations, etc.

The Conference adopted several recommendations regarding the further activity of the Society, including the establishment of crews of diversly specialized members for the solution of the most pressing general economic and local problems, the wider participation of the Society members in the standardization of automatic and control instruments.

The delegates discussed and approved the rules of the Scientific and Technical Society of the Instrument-Making Industry.

The work of the Conference and the decisions it adopted are directed towards the fulfillment ahead of the scheduled time of the plants for the development of Soviet instrument-making.

An international fair will be held in Brno (Czechoslovakia) in September 6-20, 1959 with the participation of socialist countries and also certain firms from a number of capitalist countries including Britain, Belgium, France and other countries.

The exhibits at the fair will consist of engineering and metallurgical products, including some consumer goods, produced by the engineering industry.

Among the exhibits will be included stereoscopic and electron microscopes, polarographic analyzers, vibrational strain gages for hydraulic erections, betatrons, an instrument for measuring streamlining of turbine blades and various measuring instruments such as optical, electrical and other instruments, special and laboratory equipment, instruments for testing threads, etc.

The area allocated to the fair covers 52 hectares. For housing the exhibits there are 10 pavilions of a total area of 65000 m^2 and open spaces of an area of 60000 m^2.

The "Information Bulletin" of the Brno fair, and the "Exhibition Gazette" will appear periodically at the fair.

MATERIAL RECEIVED BY THE EDITORIAL BOARD

IMPROVED SUPERVISION OF MEASURING INSTRUMENTS IN RURAL DISTRICTS

The Editorial Board continues to receive comments on S.I.Gauzner's article about the "Organization of gravimetric instrument repairs in Technical Repair Stations" *.

Thus, the Chief Inspector of the Chernigov State Inspection Laboratory, I.S.Krever, writes that RTS (Technical Repair Stations) should be entrusted with the technical supervision not only of scales and weights but also of other instruments used in agriculture. He suggests organizing training of RTS workers in the GKL (State Inspection Laboratories) and weighing-equipment repair plants and then entrusting them with the supervision of the simple measuring instruments and measures (weights, scales, meters, liters, milk measures).

According to I.S.Krever the RTS should be supplied from the start with: 1) a set of standard 3rd grade scales with three balance arms of 20 kg, 1 kg and 20 g; 2) a set of standard 3rd-grade weights; 3) 50 standard weights of 20 kg each; 4) a standard tape meter; 5) two standard flasks for checking milk measures.

Extension of the RTS equipment of standard measuring instruments and widening the sphere of their activity in metrology will, according to the author, depend on local conditions.

The technical supervision of measures and instruments by the RTS should be carried out according to agreements between the RTS and the owners of the instruments at fixed prices. The instruments should be submitted for State cheking by the RTS and not the owners.

I.S.Krever also recommends compelling the owners of instruments ,by decision of the Regional Soviet Executive Comittee, to conclude agreements with the RTS for the technical supervision of their measures and instruments and to supply to the RTS the required premises and man power free of change

The repair of weight-measuring instrument in the collective and state farms should also be carried out by the RTS and the repaired instruments submitted for State checking.

The RTS should be entrusted with rejecting old measuring instruments and replacing them with new ones.

Thus, the RTS will become an importeant link in the supervision of measuring instruments and will assist to a considerable extent the introduction of the new techniques.

The head of the Kirovograd State Inspection Laboratory, V.I. Poltoratskii, states that in his opinion a well-equipped repair plant with permanent workshops and travelling crews should become the basic instrument repair organization of a region. At present, however, due to the bad work and equipment of the Regional Local -Industry Administration repair-plants, it is advisable to entrust the RTS with the supervision and repair of weight-measuring instruments, which has already been done in the Kirovograd region.

The Kirovograd Regional Soviet Executive Committee instructed the RTS to install weigh-bridges in the collective and state farms according to plan and to repair other types of scales and exercise technical inspection of instruments by agreement with their owners. The same instruction of the Regional Committee obliged the Regional Agricultural Department to supply the RTS with standard scales and Weights and the State Inspection Laboratory of Measuring Equipment to run a course for the RTS workers on the installation and repair of scales.

Each RTS spent some 2000 roubles on a minimum amount of reference equipment; 3rd-grade standard scales were purchased from the Minsk instrument-making plant, and 50 standard 20 kg weights for each RTS were cast at the Novoukrainskaya RTS to a model supplied by one of the Kirovograd plants.

* See Measurement Techniques, No. 4, 1958 [USSR].

The transfer of the supervision over the weight-measuring instruments and the installation and repair of scales and weights in collective and state farms to the RTS is, in V.I.Poltoratskii's opinion, advantageous to the state, since it improves the condition of instruments and considerably reduces the cost of their maintenance.

Chief engineer of the Stanislav GKL (State Inspection Laboratory), B.A.Kukharkin, considers that the repair of weight-measuring equipment by the RTS is overdue, but it should be carried out in a manner to suit local conditions: the repair and installation of scales should be carried out by some of the RTS only, in order to provide sufficient work for them, and the technical inspection of the weight-measuring instruments by all the RTS. This will reduce the cost of maintenance of scales and improve the quality of repairs, since overhead expenses (including transportation) are lower and the personnel more skilled in the RTS than the local industry plants.

The supply of standard instruments and spare parts to the RTS should be correctly organized and their personnel trained by providing RTS mechanics with practical experience at weighing-equipment repair-plants; it is also advisable to issue instructions for the repair of scales.

B.A.Kukharkin considers that V.V.Petropavlovskii's * misgivings that the RTS weighing-equipment repair-crews would not have enough work if they repair instruments belonging to the agricultural organizations and that there would be financial and organizational difficulties in transferring the repair of scales to the RTS and other doubts are not sufficiently justified and are wholly surmountable.

It is not necessary to organize the repair of scales in all the RTS; in order to load the RTS with work they can also repair the Tsentrosoyuz (Central Cooperative Society) instruments. The tendency to raise the cost of repairs in the RTS will not occur with a well-organized control. The RTS will have to face expenses and difficulties at first, if it is found economically sound to transfer the repair of scales to the RTS.

As far as the work of the local industry weighing-equipment repair-plants is concerned,they will in the first place have to continue to repair scales in towns and in the second place enlarge the scope of the industrial instruments repaired by them (thermotechnical, linear and angle measuring, electrical and other instruments).

The head of the Chernovtsy GKL A.S.Kovekhov also criticizes V.V.Petropavlovskii's article and states that the Chernovtsy GKL as early as 1952 transferred the repair of scales in rural areas to the Machine and Tractor Stations. The Chernovtsy Regional Soviet Executive Committee decided to start from January 1, 1959 the operation of a base laboratory attached to one of the RTS and entrust it with the repair and inspection of the weighing equipment in collective and state farms and RTS. The City Industrial Combine will repair instruments in Chernovtsy itself and make spare parts for scales and supply them not only to its own region but also throughout the country.

The base laboratory has several travelling crews supplied with automobiles. Each brigade can service 3-4 districts, making a complete circuit of them twice a year.

The new system of repairs and inspection of weighing equipment in rural areas has the following advantages: the cost of repairs has been reduced by 10-15%; overhauls have to be done less often and thus the cost of maintanance has been decreased; the scale repairs are of higher quality; the distance covered by automobiles carrying instruments for repair has been halved; the necessity of establishing temporary branches of the GKL has disappeared, and the same number of state inspectors performs 50% more work than previously.

The chief engineer of the Tula GKL, V. S. Nikitskii, on the contrary considers the transfer of the repairs of the weighing equipment to the RTS inadvisable and thinks that the repair of the instruments will be improved if all the efforts are directed towards the improvement of the work of the existing local industry weighing-equipment repair-plants and departmental workships. For this purpose they should be relieved of work of any other kind with the exception of repairs of instruments of other types or the making of new scales; personnel should be trained, a uniform price for repairs worked out, the supply of spare parts, standard instruments, and equipment organized, etc.

A similar opinion to the one held by V. S. Nikitskii is expressed by the head of the Odessa GKL, V. E. Khontov, who considers that the existing measuring-equipment repair-plants should be strengthened technically, materially and organizationally as much as possible. The repair and checking of the weighing equipment of the Odessa region is carried out as follows: a crew of 4-6 servicemen of the weighing-equipment repair plant together

* See Measurement Techniques No. 2, 1959 [USSR].

with a technical inspector of the GKL make the circuit of all the collective and state farms of the district and repair and inspect the scales and weights on the spot.

On suggestions of the Odessa GKL the Regional Soviet Executive Committee decided to supply the instrument-repair plants with automobiles for this work.

This method of servicing the rural areas has, in the opinion of V. E. Yakhontov, justified itself.

Side by side, with a considerable speeding up of the work, this method has extended the repair and inspection coverage of instruments. Moreover, this method makes general inspections practically unnecessary, since the inspector checks all the equipment before regular repairs.

From the Editorial Board. The large number of comments on S. I. Gauzner's article shows that the problem raised in the article is pressing. The majority of our readers support S. I. Gauzner's suggestions; a part of the specialists, however, still consider that the repair of scales can be organized in the existing plants, providing certain organizational and technical measures are taken.

The Editorial Board considers that it is necessary to improve the repairs of weighing equipment in rural areas according to the prevailing local conditions.

The problem of organizing repairs of the weighing-equipment in rural areas should be discussed by the State Planning Committee of the Union Republics, which should arrive at decisions with the help of the organizations concerned.

INSPECTION OF MEASURING EQUIPMENT IN THE RURAL DISTRICTS OF MOLDAVIA

F. F. Sivokon'

During several years the Moldavian State Inspection Laboratory of Measuring Equipment has constantly reorganized the work of temporary branches and instrument-repair establishments and has achieved positive results.

The reorganization was started by checking instruments not only in District Centers but also in 2-3 village Soviets. State inspectors and repair crews started visiting the establishments themselves in collective and state farms, using transportation supplied by the owners of the instruments. The development of this procedure was retarded, however, by the lack of their own transport, and the bad equipment of the main instrument-repair establishment of the Republic, the "Vesomerpribor" plant.

In connection with the transfer of the plant to the Moldavian Council of National Economy the plant was delegated to repair and maintain the measuring equipment of the Sovnarkhoz (Council of National Economy). To a certain extent this deteriorated the servicing of the measuring equipment in rural areas.

In order to improve inspection of the measuring equipment in rural areas, a base inspection laboratory and repair shop were established on the initiative of the GKL at the Kishenev repair plant of the Ministry of Agriculture of the Republic, for the repair of scales and weights and other equipment on the spot.

The base inspection laboratory started compulsory and periodic checking and calibration of instruments for linear and angular measurements and the repair shop the repair of scales, weights, etc. The repair shop was supplied with 11 fitted trucks and an exchange stock of universal measuring instruments, table scales, and weights, thus improving and facilitating the servicing of rural establishments.

Owing to these measures, in 1958 in 22 rural districts out of 40 measuring equipment was repaired on the spot and over 200 weighbridges were installed.

Prior to 1958, the inspection of the measuring equipment in the consumer cooperatives was carried out by a small departmental workshop. In order to improve the inspection on the spot, the Moldavian Cooperative Union increased the number of mechanics employed, allocated to them 6 GAS-51 trucks, acquired standard instruments, reference weights and instruments, organized a large exchange stock of table and dial scales, weights and measures of volume; the nickel-plating of weights and scale components was organized; the repair of weights carried out in a permanent workshop. The exchange stock at the disposal of each crew is large enough to change measures or instruments at all the measuring points of any village Soviet. The crews repairs the exchange measures and instruments in well-equipped workshops at the district centers, or sends them to the permanent repair shop. Each brigade also has an assortment of weighing equipment, meters, and measures of volume for sale to trading and catering organizations, and cooperatives.

This improved method of servicing the measuring equipment of trading organizations has improved the condition of the equipment, decreased the inspection time, and eliminated the interference with the working of the various organizations due to the lack of equipment during inspection and repairs.

In the second half of 1958, the Moldavian GKL checked the work of the administrative inspection agencies supervising the measuring equipment in the establishments of the Moldavian economic region. The summary of the inspection data was submitted to the Council of National Economy. In order to improve inspection of measures and measuring instruments, establish a unified repair plant and concentrate all the material and technical means, the Council of National Economy decided to transfer to the "Vesomerpribor" plant the instrument-repair shop of the "Avtodetal" "plant. It is planned to provide the central-base inspection laboratory with additional floor-space, equipment and standard instruments, to establish base laboratories in Bel'tsy and Bendery, to compile capacity calibration tables for storage of oil and other products, to organize at the training center training and refresher courses for instrument repair specialists, to assign means for capital construction.

In December, 1958, the Council of Ministers of the Moldavian SSR transferred to the "Vesomerpribor" two departments of the technical repair stations with standard repair shops, electrical power stations, garages and other services. On the basis of these RTS permanent interdistrict instrument-repair shops with travelling crews on fitted-out trucks were established in addition to the existing stations. The factory was also supplied with 15 fitted-out trucks and two automobiles, thus improving the technical inspection department, bringing it closer to the places where the equipment is used and enlarging the sphere of the inspected and repaired measures and instruments.

The "Vesomerpribor" plant will also receive the weighing-equipment repair shop of the Moldavian Cooperative Union.

Thus, the unification and enlargement of the instrument repair base has been completed, in the main, and a large instrument repair plant has been set up.

In organizing the inspection and repair of measures and measuring instruments in rural districts, we take into account the accumulated experience and base ourselves on the prevailing conditions. Usually a state inspector is put in charge of three or four rural districts, conveniently placed and connected by road. According to the schedule of state inspection visits and repairs, a state inspector with a repair crew of 8-10 people leaves the center on a fitted-out truck for the various districts. Two such crews are sent to large districts. The District Soviet Executive Committee in conjunction with agricultural inspection workers amends and approves the inspection repair schedule of instruments in collective and state farms, RTS and industrial establishments. The schedule is brought to the notice of all the organizations concerned. For more efficient operation each weighing-equipment repair crew is divided into 3-4 groups.

The collective and state farm administrations provide premises for a workshop and food and accommodation for the inspector and mechanics. The time spent in any collective farm depends on the amount of work and number of skilled mechanics.

On arrival in any collective or state farm the state inspector first of all records the number of measures and measuring instruments used and enters them in a special record book. The list is compiled by checking against last year's data and the book-keeper's records and by personal inspection of the measuring equipment of all the crews, farms, workshops, stores, etc. The inspector carries out similar work in all the establishments and organizations on the territory of the collective farm or the settlement. At the same time he sorts out the equipment which

can be left in use and that which must be checked or repaired. He also checks and afixes seals to the equipment repaired by the crew.

The state inspector also renders assistance to the administrations of the collective and state farms, regarding improvements in servicing the measuring equipment, insists on people being put in charge of its maintanance and instructs these people in the methods of using the equipment and maintaining it.

The inspector also checks the methods of utilization of the measuring equipment and the accuracy of measuring grain, fodder, milk, oil products, etc. The general inspection data is summarized and, if necessary, submitted for discussion to the collective farm administration or District Soviet Executive Committees. The personnel of the district agricultural inspection and the RTS take part in the general inspection. General inspections confirm that, wherever maintanance is carried out according to the new methods, the measures and measuring instruments in the collective farms are, with very few exceptions, accurate and have valid state seals.

Great damage is caused by the insufficient number of scales in the collective farms, which are obliged to transport them from place to place. The scales are used in the open, their components rust and are often lost in transportation. It is urgently required to produce scales and weights with a noncorrosive covering, thus reducing considerably the cost of maintenance and repairs and facilitating their servicing.

It is necessary to establish in collective and state farms and RTS conditions, which would ensure a constant maintenance of instruments in an efficient state. It is necessary to insist on certain people being made responsible for the maintenance of the measuring equipment, instruct them as often as possible in the art of maintenance, hold courses, conferences, attracting to them the agricultural inspection and RTS personnel.

In order to acquaint as many people as possible with the technique of measurements in agriculture and the rules of maintaining the equipment, posters and brief instruction were issued on the initiative of the GKL for the personnel using the measures and instruments on a wide scale.

The laboratory participated in compiling the "Handbook of the Collective Farm Chairman" issued by the Ministry of Agriculture of the Republic. The handbook contains a special section on measures and measuring instruments used in agriculture; this section explains the regulations and assignment of responsibility for the conditions of the measuring equipment and the manner in which to maintain it.

The laboratory has also prepared a draft regulation on administrative inspection of measures and measuring instruments in collective farms. Drafts for lectures, reports and talks on the role and importance of the technique of measurement in agriculture and the inspection of the measuring equipment have been prepared. The inspector should supplement his talks and reports at the collective and state farms and RTS by local examples and facts.

The new methods of inspection of measures and measuring instruments, consisting in sending the personnel involved to the places where the equipment is being used, is appreciated by collective farm administrations, heads of establishments and District Soviet. Executive Committee.

Dozens of letters and comments approving the work of the weighing-equipment repair crews and state inspectors confirm the correctness and efficiency of the new methods of inspection of the measuringequipment in rural areas.

It seems to us that side by side with discussing the best methods of inspection in rural areas, it is necessary to establish the practice of checking and repairing the measuring equipment on the spot.

LET US MAKE BETTER PREPARATIONS FOR INTRODUCING REGULATION 12-58

B. L. Sokolov's article "Let us prepare for a changeover to new forms of state inspection of measuring equipment"*, which was opened for discussion, produced a number of comments by readers of our journal. In the main the letters received by the editorial board point to the pressing nature of the problems dealt with in the article.

V. N. Solov'ev (Ivanovo) notes that the unsatisfactory state of the basic instrument-repair establishments has an important effect on the condition of the measuring equipment and considers that a radical improvement of this condition, the training of personnel for instrument-repair establishments, provision for their materials and technical requirements, their supply with special equipment and testing instruments and a systematic supervision of the repairs should be solved on a centralized basis.

Considering the greater part to be played by travelling test laboratories in the transition to the new methods of inspection, V. N. Solov'ev considers that the centralized reequipment of trucks according to a single plan should be carried out.

The method of organizing the "interdistrict area" in connection with the assignment of districts to state inspectors, requires, according to him, immediate solution.

V. N. Solov'ev quite correctly also notes that "The successful transition to new methods of state inspection of measures and measuring instruments and, what is even more important, ensuring their constant accuracy and efficiency will depend not only on the Committee of Standards, Measures and Measuring Instruments, but also in a decisive degree on the state of the measuring equipment in the areas of the Councils of National Economy, industrial departments of the local soviets and other administrations."

M. I. Malakhov (Tombov) considers that it is completely inadmissible to direct the same requirements to all the working components as well as newly produced measuring instruments.

In M. I. Malakhov's opionion a rule should be established by which instruments in use and satisfying production requirements should not be rejected on the grounds of low accuracy so as not to scrap instruments on purely formal grounds.

B. N. Vorontsov (Gor'kii) suggests that the Institutes of the Committee of Standards, Measures, and Measuring Instruments should be relieved of the work of checking standard instruments, and that this work should be transferred to 1st-grade laboratories, which have the required equipment, and that the problem of establishing base laboratories under the control of the Committee should be considered, in order to improve the checking, calibration and repair of standard instruments of the laboratories attached to various establishments.

Fully supporting the idea of granting the state inspector the right to decide whether an instrument should remain in use, although it does not satisfy all the requirements of the specification, B. N. Vorontsov considers at the same time that it is not advisable to draft special instructions with a reduced number of points to be checked, since one cannot forsee all the possible cases and such an attempt would only tie the hands and reduce the initiative of the people engaged in testing.

V. V. Petropavlovskii (Tambov) objects to granting the state inspectors the right to approve instruments whose readings are accurate only in the range in which they are being used, and considers that the granting of such "wide, very indefinite and almost uncontrollable rights to state inspectors" can lead in the near future to the infringement of unified measurements. V. V. Petropavlovskii suggests that courses for the Committee workers should give the most attention to "intricate checking and checking of standard instruments, and most of all study the organizational questions connected with rule 12-58".

Developing his idea on the necessity of improving and simplifying the reporting on and accounting for the time spent by the GKL operative workers, V. V. Petropavlovskii considers that the existing system of "scrupulous accounting" of state inspectors according to tasks and man-hours should be unified and simplified when the new methods of state inspection come into force, namely the state inspectors should account for their work during one month in a district, in a plant, for a given assignment, etc.

* See Measurement Techniques No. 2, 1959

P. U. Markov (Tomsk) notes that in the light of the decision of the 21st Congress and the June Plenary Session of the Central Committee of the CPSU regarding the tasks facing the Industrial Test Laboratory workers, they should possess not only metrological knowledge, but should also be acquainted with production technology, machine and cutting tools.

Owing to the rapid development of the measuring equipment both in scope and intricacy, due to industrial progress, the role played by Industrial Test Laboratories has been greatly enhanced, since they are now expected to ensure that the plants use the latest achievements of science and technology in the sphere of measuring instruments.

Considering the relatively narrow objectives of the factory Technical Inspection Departments and the impossibility of developing adequately the Test Laboratories subordinated to them, P. U. Markov thinks that in large and medium engineering plants the test laboratories should be transferred from the Technical Inspection Departments to the Chief Engineer's service, where they will be able to solve better and more completely the problems of introducing new measuring equipment, new methods of measurement, and active means of inspection, of analyzing by their geometrical parameters various methods of machining, etc.

Noting the effective work of the Committee's Interchangeability Bureau in servicing several plants in the eastern regions of our country by means of travelling crews, P. U. Markov at the same time stresses the necessity of organizing this work on the spot in order to satisfy the requirements of one or several adjoining Councils of National Economy areas by training in the Interchangeability Bureau the required specialists. He also considers it necessary to periodically hold courses for industrial workers, on modern methods and means of inspection, and courses increasing their knowledge in the sphere of metrology.

Z. B. Korchmar' (Nikolaev) writes about the advisability of organizing with the assistance of Institutes or large GKL courses for raising the qualifications of the workers employed by the Committee. The curriculum of these courses should include practical work at the plants in checking the adherence to standards and inspecting measuring equipment, in introducing new measuring techniques, etc. Z. B. Korchmar' considers that the total amount of fees collected should be excluded from the indexes of GKL's work.

In N. L. Kapustin's (Petrozavodsk) opinion the GKL plans of fee collections should be reduced in the new methods of inspection, since otherwise the GKL may in cases of a nonfulfillment of the plan impose, without sufficiently good reasons, compulsory state inspection on plants which have administrative inspection agencies.

B. I. Lachinov and P. I. Liberman (Nikolaev) write that in order to improve the enforcement of standards and technical specifications, the workers concerned should be trained at short courses (15-20 days) in basic branches of industry instead of seminars.

O. A. Maslov (Krasnodar) considers that in order to avoid overlapping in the work of the GKL inspection points in instrument-making plants and industrial laboratories, it is advisable for the Inspection and Testing Points and factory personnel to organize inspection testing jointly; he also suggests that instruments, which have been manufactured for a long time and whose technical characteristics are well known, should be tested less than twice per year.

From the Editorial Board. It will be seen from the brief review of the letters received by the Editorial Board that relatively little attention has been paid in them to the problems of practical preparation of the GKL and the administrative inspection agencies for the changeover to the new method of inspection.

In the forthcoming reorganization a very important part will be played by the preparation of all the required conditions for the assignment of responsibility for various districts to the GKL personnel, the preparation of all the required conditions for organizing inspection in Councils of National Economy areas and in establishments, the organization of measuring instrument repairs, organization of technical inspection of instruments, wide organizational and instruction work, etc.

It would be desirable that in order to exchange experiences, the readers of this journal should report on the pages of this journal the concrete steps taken by their GKLs in preparation for the new method of inspection.

ONE MORE METHOD OF SAVING METAL

A. D. Snagovskii

When observing the use, repair and checking of imported threaded and smooth micrometers and those produced by our instrument-making industry (the "Kalibr" and "Krasnyi Instrumental'shchik" plants) with ranges including and larger than 0-25 mm, one is bound to wonder why the frame, stem and other parts of our micrometers are so massive ?

When comparing micrometers of the "Kalibr" plant and those made by Swedish and Japanese firms of the same ranges (0-25 mm) and with the same accuracy of measurement, it was found that the "Kalibr" micrometer weighed 147 g more than the others. The measuring effort of the micrometers is the same (according to the test specification); hence the excessive sturdiness is not justifiable.

If the number of measuring instruments produced in our country is considered, it becomes clear that it is possible to save many dozens of tons of high-grade steel per year.

AN IMPORTANT TASK OF NATIONAL ECONOMY

The Editorial Board has received a number of comments on the article entitled "Preventing losses in liquid fuels and lubricating oils" * by I. G. Entis and V. P. Safanova.

The authors of these comments confirm the typical nature of the defects cited in the article regarding the accounting system and measurements of liquid fuels and lubricating oils in various establishments.

The chief engineer of the Chernigov State Inspection Laboratory (GKL) of Measurement Equipment, M. A. Svirlov, agrees completely with the conclusions drawn by I. G. Entis and V. P. Safanova on the defects in measuring fuel and lubricating oils in various establishments. It should be added that in various establishments and other organizations, means are often lacking for measuring lubricating oils. Fuel and lubricating oils are either measured out in buckets and home-made tins, or simply left in barrels out of which the drivers and other consumers help themselves the best way they can.

It is necessary in the shortest possible time to supply the oil industry with special oil-pumps which measure in units of weight.

A. S. Poroshin (Tula GKL) notes that in the Tula region " there still exist establishments which have no proper storage tanks or distribution premises, which have not completed calibration tables for their reservoirs and lack means of measurement".

Similar comments are made by A. S. Doktorovich and S. S. Nisenbaum (Dnepropetrovsk GKL), B. I. Lachinov and P. I. Liberman (Nikolaev GKL), and N. V. Nikolin (Kar'kov).

All the contributors support the proposal for drafting instructions of a practical nature on the organization of fuel and lubricating oil storage. Moreover, it is suggested that not only the requirements of medium size plants should be considered, but also that of small establishments, where the accounting system of fuel and lubricating oils is even worse.

N. V. Nikolin notes that in the majority of Machine and Tractor Stations (Technical Repair Stations) and state farms (especially in isolated places and newly cultivated lands) calibration tables either do not exist at all, or are badly compiled, since neither practical instruction on calibrating all types of reservoirs nor auxiliary tables, which simplify this work, are available on the spot. Many establishments are, therefore, obliged to engage private individuals at high fees for compiling calibration tables of doubtful quality.

N. V. Nikolin considers it necessary to issue special handbooks for measuring stationary reservoirs under various conditions. The success of compiling calibration tables by the local personnel will depend on the simplicity of the proposed technique and the availability in the handbook of all the required auxiliary tables.

In describing calibration tables N. V. Nikolin cites facts,showing that many plants and workshops which make storage tanks attach to them tables compiled in different ways (approximately, not according to the specified manner, etc.). Thus, for instance, the Tuapse engineering plant only sends to its customers an instruction on how to compile calibration tables, instead of attaching a centimeter calibration chart. These instructions include a coefficient K_{ts} taken from calibration tables of railroad tank cars. The Erivan sheet-metal plant does not supply calibration tables for each 26 m^3 tank, but makes the same table fit several tanks, etc.

The majority of specialists who commented on the article disagree with the suggestion of the authors of this article to permit "substitute measures" and lower the accuracy requirements of the measures used.

Thus, M. A. Svirlov writes: " I consider Comrades Entis and Safonova are incorrect in suggesting that the permissible error for petrol pumps, 2nd grade industrial capacity measures, metric dipping sticks, and tape-measure plumb-lines should be relaxed. On the contrary, the existing tolerances are too wide and they should be decreased".

M. A. Svirlov considers that in order to eliminate the outlined defects, it is necessary to manufacture and sell the measuring equipment for fuel and lubricating oils in a centralized manner.

The opinion of A. S. Poroshin coincides with that of M. A. Svirlov on the point of the necessity of increasing the manufacture of metric dipping sticks, oil densimeters, and petrol pumps. It is impossible to agree to the lowering of the accuracy of fuel and lubricating oil measuring equipment, since it makes the prevention of losses in these materials more difficult.

The use of normal calibrated buckets cannot be accepted even as a temporary measure, since it sharply decreases the accuracy of oil measurements and contravenes,on medical grounds,the regulation for filling automobiles with ethylated petrol.

A. S. Doktorovich and S. S. Nisenbaum adopt a different attitude. They consider that the tolerances for measuring rods and capacity measures are too stiff and could be probably be revised, but on the other hand, they protest vigorously against using buckets, etc., considering that all the work in eliminating "substitute measures" will thereby be destroyed.

The general opinion of all the contributors amounts to the necessity of raising in the State Planning Committee of the USSR the problem of the production and centralized supply to the petroleum industry of metric dipping sticks, tape-measure plumb-lines, 2nd grade industrial capacity measures, oil densimeters and other oil measuring equipment.

B. I. Lachinov and P. I. Liberman report their experience: "In our region the acquisition of a set of oil densimeters or a metric dipping stick is a difficult problem. In view of this the Nikolaev weighing-equipment repair plant started, on the initiative of the GKL, to produce 2nd grade industrial capacity measures, and we recommend oil dealers who have no oil densimeters to determine, as a temporary measure, the density of oil by weighing 10 liters measured out by 2nd grade industrial capacity measure on 20 kg table scales.

The state of metric dipping stick and tape-measure plumb lines is even worse. The Nikolaev GKL plans to produce at the weighing-equipment repair plant 300 mm nickel plated weights with a device for fixing them to ordinary tape-measured shortened for the purpose. This is also a temporary measure, since for correct measurements of oil products it is necessary to manufacture these instruments industrially."

B. I. Lachinov and P. I. Liberman consider that technical inspection of motor tanks should be carried out annually, since in their opinion large amounts of oil products are lost through leakages during pumping, owing to defective hoses.

In N. V. Nikolin's opinion the calibration tables for vertical storage tanks with different girdle diameter (capacity of 500 m^3) and horizontal storage tanks with spheroidal and cone-shaped bottoms should be revised, since when they were compiled in several instances, very serious errors were made (different girdles of vertical tanks were not measured, spheroid bottoms were calculated as if they were spherical, or by the method of combined

substitution, etc.), thus committing large errors in measurements. N. V. Nikolin considers that tolerances of calibration tables for horizontal storage tanks should be fixed according to their size and the height of liquid in them.

In N. V. Nikolin's opinion the setting-up at each Institute of Measures and Measuring Instrument of a special group for calibrating storage tanks would greatly improve the accounting system of residual oil products and other valuable liquids.

In conclusion it should be noted that the general opinion of the contributors is that the present enlargement of the garages will lead to a better organization of oil measurements and will facilitate the required supply of measuring equipment.

From the Editorial Board. The concrete proposals made by the authors of the published comments have required attention for a long time. The solution of the above problems of storing and measuring oil products will save millions of roubles per year for the national economy. Hence the Councils of National Economy, State Planning Committees of the Union Republics and the State Planning Committee of the USSR should have attended to these questions a long time ago.

THE FORGOTTEN CERAMIC WEIGHTS

G. S. Poritskii and A. M. Voronov

Before the Great Patriotic War we produced ceramic weights of the 2nd and 3rd grade up to 500 g. At present, for unknown reasons their manufacture has been discontinued.

The renewed production of ceramic weights would provide our economy with considerable savings, since the making of ordinary weights on a country-wide scale involves a large quantity of ferrous metals. Moreover, these weights wear rapidly and have to be repaired, thus involving considerable additional expenditure. Ceramic weights, even in the most unfavorable conditions, do not require repairs for a long time. Even now one can come across ceramic weights manufactured 20 years ago and yet in perfect condition. Ceramic weights are moreover indispensable in establishments and laboratories where medical and hygenic conditions are especially stingently enforced.

It is high time to recommence the production of ceramic weights of various grades of accuracy according to an improved technique, taking into account the latest achievements of science and technology. They can be made in constructional ceramic plants located in different parts of the country.

From the Editorial Board. A similar note of the same contributors was published in the Kuibyshev paper "Volzhskaya Kommuna" on May 27, 1959. The Editorial Board published the note of G. S. Poritskii and A. M. Voronov because the problem raised by them is of considerable importance not only for the Kuibyshev economic region. This problem should be solved in the State Economic plans of the Russian Federation and the Ukraine, the two Republics which have all the possibilities of restarting the production of ceramic weights on the required scale.

IN THE COMMITTEE OF STANDARDS, MEASURES AND MEASURING INSTRUMENTS

A NEW STATE STANDARD: "ELECTRICAL MEASURING INSTRUMENTS. GENERAL TECHNICAL SPECIFICATION" (GOST 1845-59)

S. M. Stolyarov

The Committee of Standards, Measures and Measuring Instruments approved GOST 1845-59 entitled: "Electrical Instruments. General Technical Specification".

The new standard has been evolved by the All-Union Scientific Research Institute of Electrical Measuring Instruments (VNIIÉP) and replaces GOST 1845-52.

The revision and replacement of the old GOST for electrical measuring instruments is due to the requirement of keeping up with the present level and the advances in the technique of the Soviet and foreign instrument making industries for the last seven years.

The following peculiarities and differences between the new standard and GOST 1845-59 are most essential.

The new standard applies not only to instruments which measure electrical quantities, but also to instruments which are used as secondary devices for measuring nonelectrical quantities by electrical means. In this connection it was found possible to annul GOST 2261-43 entitled: "Electrical Instrument for Thermotechnical Measurements. General Technical Specification".

The coverage of ac instruments has been extended to 10 cps at the low-frequency end and to 20,000 cps at the high end.

New accuracy grades have been introduced: for electrical measuring instruments grade 0.05; for auxiliary components grade 0.02.

The ratio of error of the standard to the measured instrument has been considerably reduced. It is now taken as 1 : 5 instead of the previous figure of 1 : 3, thus increasing considerably the guarantee of accurate calibration.

The requirement for the stability of instrument with climatic and mechanical disturbances has been raised. In addition to the operating conditions, limiting conditions for temperatures $-60°$ and $+65$°C have been specified.

A group of instruments normal in design but with increased mechanical strength has been introduced. The object of introducing this group is to increase the life of instruments under shop and laboratory conditions. Portable and rack-mounted instruments of this type and of all grades of accuracy must sustain without damage or loss of accuracy shocks with a maximum acceleration of 15 m/sec^2 and of 10 m/sec^2 for recording instruments, at a rate of 80-120 shocks per minute. The duration of tests must not be less than 15-30 minutes.

Mechanical stability requirements for vibration-proof instruments have been raised (200 m/sec^2 instead of 70 m/sec^2, according to GOST 1845-59).

For the first time the number of shocks and their intensity with an acceleration not less than 1000 m/sec^2 has been specified for shock-proof instruments.

GOST 1845-52 embraced instruments of 10 different systems, whereas the new standard includes electrical measuring instruments of 18 different systems, thus reflecting the quantitative and qualitative growth of the Soviet instrument-making industry.

The deviation tolerances for a number of instruments have been tightened up. Thus, deviations in the readings of shock-proof, ink recording, miniature and small instruments, grade 0.05 and ac grade 0.1 instruments and those of moving-iron and ferrodynamic instruments, when checked on dc, should not exceed one and a half times the basic error of the instrument as against twice the basic error allowed by GOST 1845-59.

Balance requirements of the vibration-proof instruments have also been raised. The dip angle of the portable instruments grade 0.5-1.0 is fixed at 20° and that of grade 1.5-4.0 instruments at 30°; for rack-mounted instrument grade 0.5-1.0 the dip angle has been fixed at 30° and for the grade 1.5-4.0 instruments, at 45°.

The requirement with respect to the current or voltage wave form and duration of measurement have been specified.

External magnetic or electrical interference has been specified for instruments of various accuracies. Instead of four grades of magnetic screening two have now been specified, thus simplifying the scale calibration.

In order to improve the dynamic characteristics of instruments, a new requirement has been introduced referring to the ratio of the first deflection to the stable-state value of the instrument, which for recording instruments should not exceed 1.1 and for indicating instruments 1.5.

A new requirement for insulation testing at high humidity has been introduced. Insulation-resistance requirements for instruments and their auxiliary parts have been raised.

Overload requirements for the series circuits of recording instruments have also been raised. A new requirement for testing the overloading of ratiometers, when one of its circuits is open, has been introduced.

Instrument cases have been classified with respect to their screening properties, their requirements specified and their method of testing determined.

Requirement with respect to the instrument components have been considerably extended (32 items instead of 12 of GOST 1845-52), including the one regarding the indicating mechanism.

The markings of the scales have been considerably abridged by means of using conventional notations. A number of conventional markings have been changed in order to bring them in line with international recommendations.

The section dealing with methods of testing and requirements of the testing equipment has been considerably enlarged. For the first time the method of testing the effect of the wave form of magnetic and electrical fields and screening of cases has been specified.

A new section entitled "Completeness of supplies" has been introduced.

The section on "Packing and storing" has been enlarged. The storage-temperature range has been extended for instruments of groups B and C.

The standard has been enlarged by two supplements: a short list of basic concepts with definition and a list of conventional notations and signs, inscribed on the instruments and auxiliary equipment, thus eliminating the part of GOST 2930-45 dealing with conventional notations.

The standard requirements have been made to conform with international recommendation regarding indicating electrical measuring instruments.

With respect to several parameters, more stringent requirements than those specified internationally have been adopted, for instance, with respect to effects of temperature, magnetic field, balancing, and others.

All the enumerated requirements included in GOST 1845-59 are aimed at considerably raising the accuracy and reliability of instruments increasing their range of measurements and, hence, the sphere of application of the standard.

I. NEW SPECIFICATIONS FOR MEASURES AND MEASURING INSTRUMENTS APPROVED BY THE COMMITTEE

(Registered in May-June, 1959)

NEW STANDARDS

GOST 8625-59. Manometers, manometric vacuum gages and vacuum gages of general use. Replacing GOST 8625-57.

GOST 9177-59. Liquid in glass thermometers (nonmercury). Types and technical requirements. First specification.

NEW INSTRUCTIONS FOR TESTING MEASURES AND MEASURING INSTRUMENTS

Instruction 68-59 on testing tape comparator meters.

Instruction 223-59 on testing standard measuring telephones.

Instruction 224-59 on testing "Artificial Ear" instruments.

Instruction 283-59 on testing instruments for checking dimensions of details during the operation of cylinder-and-cone grinding machines.

OPERATING INSTRUCTIONS FOR TESTING MEASURES AND MEASURING INSTRUMENTS APPROVED BY THE MEASURING INSTRUMENT DEPARTMENT OF THE COMMITTEE

Operating instruction No. 175 on testing photometric electric incandescent lamps.

II. MEASURES AND MEASURING INSTRUMENTS EXCLUDED FROM THE STATE REGISTER

Standard portable scales with trade mark OR3, grade 3 of 20 kg, State Register No. 231.

Resistance box, trade mark MSR-47, State Register No. 346.

Hardness meter, trade mark TK, State Register No. 606.

Hardness meter type TSh, State Register No. 619.

Domestic table-type scales type VNB, State Register No. 681.

Resistance box, trade mark MSR-54, State Register No. 1017-56.

Domestic spring scales, trade mark BV-6 and BV-10. State register No. 1197-58.